THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

THE INSTITUTION OF

PRODUCTION ENGINEERS JOURNAL

10 CHESTERFIELD STREET . LONDON . W1 Telephone: GROsvenor 5254/9

Vol. 34, No. 3 *Price 10/-* *March 1955*

CONTENTS

"EDUCATION AND RESEARCH FOR PRODUCTION" by Professor E. J. Richards, M.A., B.Sc. 129

THIRD CONFERENCE ON "PROBLEMS OF AIRCRAFT PRODUCTION"

PROGRAMME 132

Session I

"AIRCRAFT DESIGN PROBLEMS AND TRENDS" by A. E. Woodward-Nutt, M.A., F.R.Ae.S. 133

DISCUSSION 146

CONFERENCE LUNCHEON 149

Session II (i)

"PROBLEMS OF FORGING" by G. W. Richards . . . 152

Session II (ii)

"MACHINING AND FORMING PROBLEMS OF INTEGRAL CONSTRUCTION" by E. D. Keen, B.Sc.(Eng.), F.R.Ae.S., and A. W. Menzies 158

JOINT DISCUSSION 180

REPORT OF THE ANNUAL GENERAL MEETING, 27th January, 1955 . . . 189

REPORT OF THE MEETING OF COUNCIL, 27th January, 1955. 190

ELECTION OF MEMBERS 192

EXTRACTS FROM LOCAL SECTION REPORTS 193

NEWS OF MEMBERS 197

The Institution of Production Engineers does not accept responsibility for any statements made or opinions expressed in any papers published in the Journal of the Institution.

EDITORIAL COMMITTEE

M. Seaman—Chairman
Sir Walter Puckey—President of the Institution
G. R. Pryor—Chairman of Council
H. G. Gregory—Vice-Chairman of Council
J. M. Brice
E. G. Brisch
W. J. Dimmock
A. A. Francis
K. J. Hume
H. Peter Jost
H. G. Shakeshaft
P. Spear
B. E. Stokes

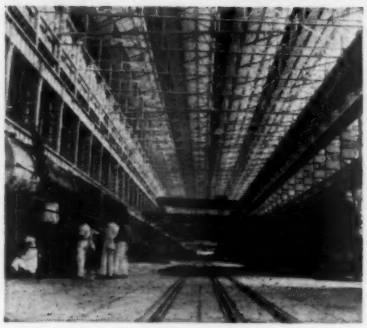
EDITOR

M. S. C. Bremner

SECRETARY OF THE INSTITUTION

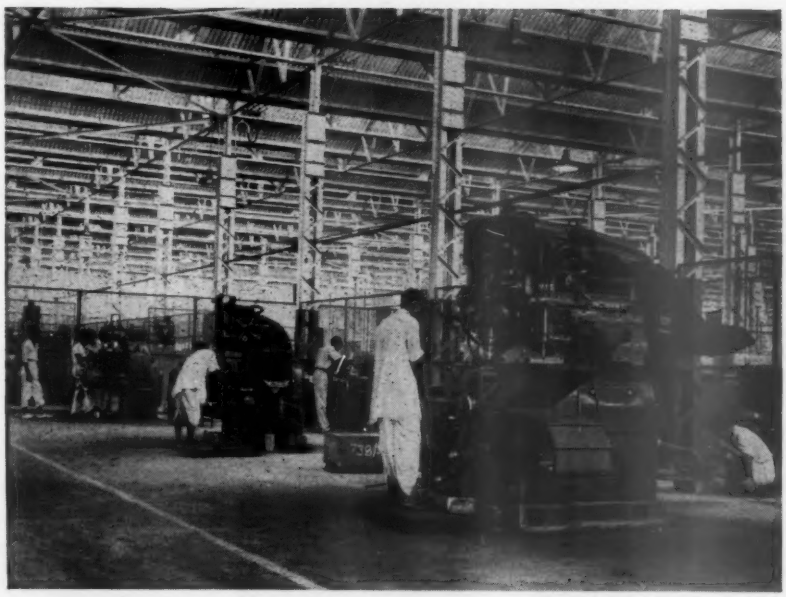
W. F. S. Woodford

CINCINNATI APPLICATIONS IN MODERN INDUSTRIAL PRODUCTION



INDIAN RAILWAYS
use
CINCINNATI
MACHINE TOOLS

Machine Tools bearing the name 'CINCINNATI' are prominent in engineering workshops throughout the world.
In the largest locomotive works in all Asia (at Chitteranjan, 150 miles from Calcutta) Cincinnati milling, profiling, diesinking and cutter grinding machines perform an important role in ensuring continuity of production.



CINCINNATI

DIAL TYPE, 2.M.I. and HYDROMATIC MILLING MACHINES

HYDROTEL DIESINKERS

CUTTER GRINDERS

Engineers in far distant places rely upon CINCINNATI

CINCINNATI MILLING MACHINES LTD., BIRMINGHAM, 24

Sales Representatives for Gt. Britain and Northern Ireland: Charles Churchill & Co. Ltd., South Yardley, Birmingham 25
Sales Representatives for India and Pakistan: Heatly & Gresham Ltd., London, S.W 1
When replying to advertisements please mention the Journal

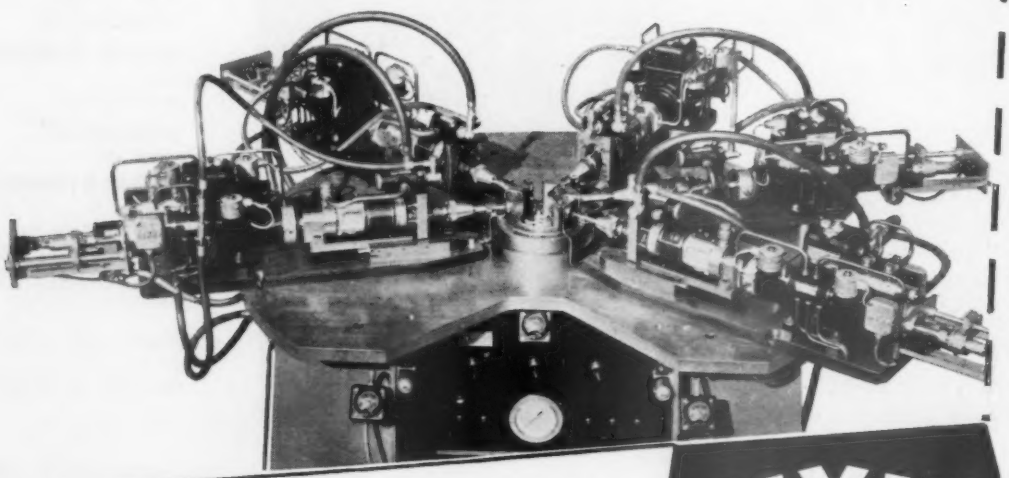
A week's work in a day!

MAXAM engineers were called in early in the development of this machine; now it automatically drills, forms and faces five holes—the largest 1½" deep—in 28 seconds. Previous methods had taken over 3 minutes, so that production is now 500% up and the machine does more than a week's work in a day!

In this case the MAXAM system comprised five hydro-pneumatic feed units, fitted with air-motors and coupled to the necessary air pilot and electric valves providing sequence, interlock and isolation control.

Your problem may be in refrigerator assembly, furniture glueing, the placing of bottles in their crates or in any other field. Whatever it is, you really should consider the possibilities of MAXAM automatic operation. May we send you a descriptive leaflet or a catalogue?

MAXAM Dept. C, THE CLIMAX ROCK DRILL AND ENGINEERING WORKS LTD.
4, Broad Street Place, London, E.C.2. Works: Carn Brea, Cornwall.



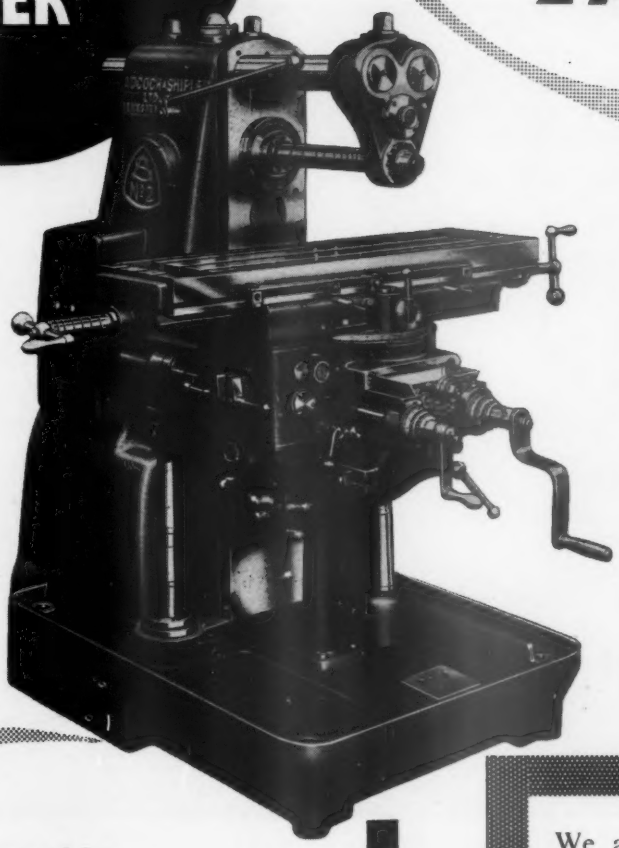
and for your job too—

MAXAM PNEUMATIC SYSTEM

TAS/CX 563

THE
ADCOCK & SHIPLEY
40" x 10" UNIVERSAL
ALL GEARED
MILLER

the QUALITY and
ACCURACY
of larger machines is supplied
in our
2 AGU



- HARDENED and GROUND GEARS
- 12 speeds 30-600 or 60-1200 R.P.M. or alternatively 24 speeds 30-1200 R.P.M.
- 4 or 3/5 H.P.
- TAPER ROLLER BEARINGS
- PRECISION
- RIGIDITY

We believe this machine will suit YOUR JOB and YOUR Budget...because rarely used and expensive features only have been omitted.

We also manufacture Drilling Machines, Special Purpose Machine tools and Lens Grinding Machines.

ADCOCK & SHIPLEY LTD.

ASH STREET · LEICESTER · ENGLAND

Telephone: Leicester 65154-6

Telegrams and Cables: "ADCOCK, LEICESTER"

DSG LATHES

for increased production and accuracy

17" SWING CENTRE LATHE

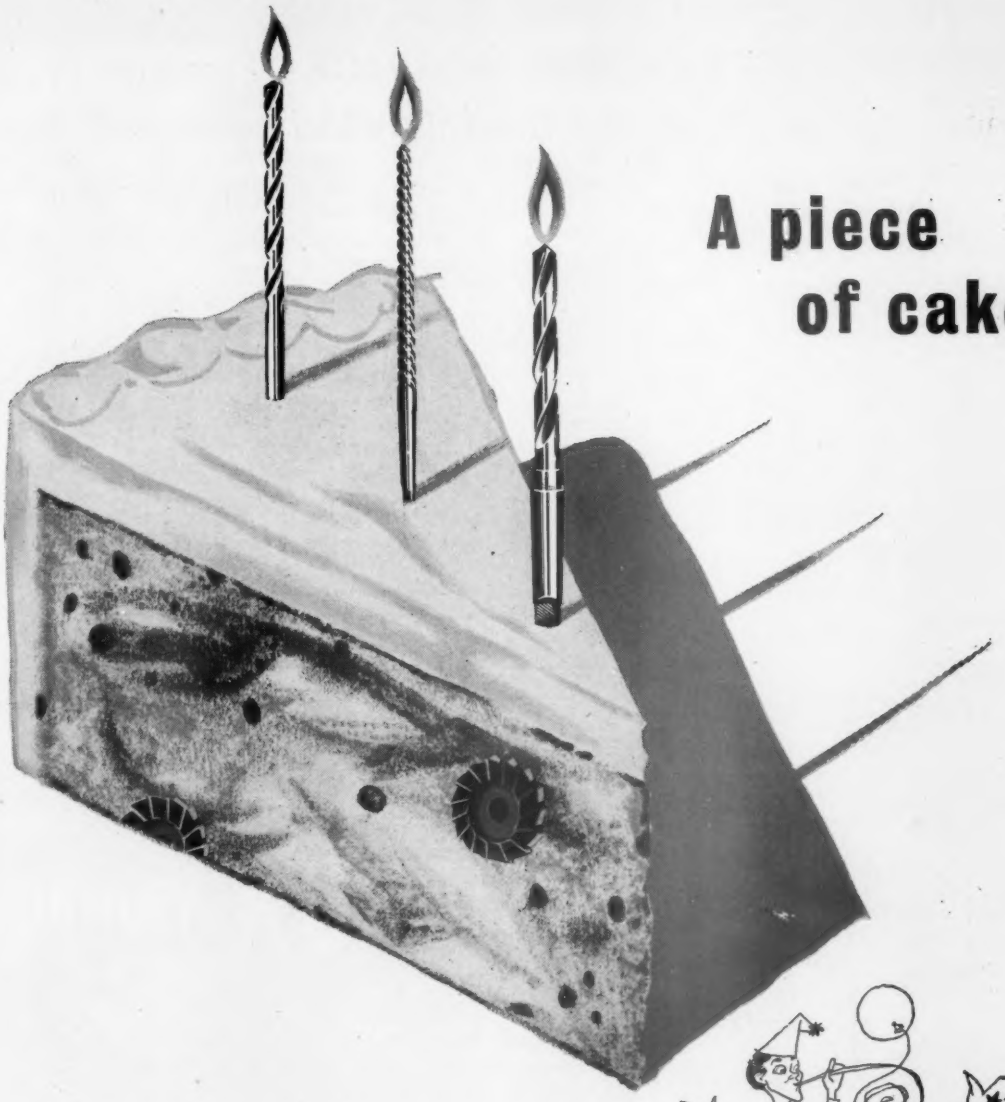
We manufacture:- 13 TO 30 INCH SWING CENTRE LATHES · SURFACING AND BORING LATHES · TOOLROOM LATHES

Dean Smith & Grace
KEIGHLEY LIMITED ENGLAND

TELEPHONE NUMBER 4274 (5 LINES)

CATALOGUES ON REQUEST

A piece of cake



At first sight, wholly irrelevant, but those of us with growing sons know, only too well, the full import of the phrase . . . 'O.K. Dad —it's a piece of cake!' It implies, at once, absolute confidence, a certain facility for doing a job quickly and well. In other words . . . 'it's as good as done!' There's nothing more to add, is there?

MONKS & CRANE LTD the twist drill specialists

BIRMINGHAM • LONDON • MANCHESTER • GLASGOW

When replying to advertisements please mention the Journal

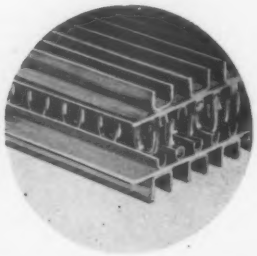
A Great Development in Steel and Stainless Steel Working

A HYDROGEN BRAZING SERVICE—Furnace Brazing supercedes welding for the following reasons :-

1. Heavy and light gauge steel parts can be furnace brazed with joints as strong as the parent metal.
2. In furnace brazing there is no general or local distortion.
3. Furnace brazing gives a bright finish eliminating subsequent normalising, machining or sand blasting.
4. Any number of joints however intricate can be furnace brazed in one operation.
5. Furnace brazing gives consistent results independent of the skill of the operator.
6. With furnace brazing there is deep penetration over the whole of the mating surfaces, however extended.
7. There is now no limit in furnace brazing to the size of assemblies however large or small.
8. Most stainless and free-machining steels are suitable for furnace brazing.
9. There is complete resistance in the joints to vibration and impact.
10. With furnace brazing complicated machining can be eliminated with reduction of production cost, material losses and time in that components can be pre-fabricated in bulk and furnace brazed into single and lighter units.

For copper brazing the assemblies can be as small as a pea with a single joint.

or as large as this heat exchanger with 50,000 joints.



Pin-Fin Heat Exchanger
(for The Superheater Co. Ltd., London).

Copper brazed heat exchanger envelopes are shown in the illustrations with extended surface on both sides of the parent plates. Complete parts of an envelope are lightly spot welded together and the whole unit is copper brazed in one operation. The envelopes withstand an internal hydraulic test pressure of 2,000 lbs./sq. in. Envelopes of the type shewn — measuring 7' 6" × 4' 0" and weighing over 450 lbs. have been brazed in one operation. The design was originated by the Air Preheater Corporation of America, who have developed it mainly for gas turbine heat exchangers and it is at present being applied successfully in this field. Heat Exchangers Ltd., a subsidiary of the Superheater Co., Ltd., are the British manufacturers of this apparatus.

You send us the components we do the rest.

HEAT TREATMENT IN HYDROGEN UP TO 1550 Deg. C.

Send us particulars of your problems

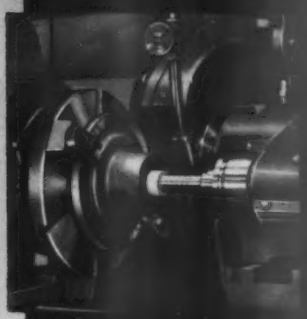
THE FURNACE BRAZING CO LTD

KEPSTON SIDINGS
MILNATHORT
KINROSS-SHIRE
Kinross 3292

OR

BERKHAMSTED
HERTS
Berkhamsted One

STANDARD MODEL 12" x 24"



INTERNAL GRINDING

FACE GRINDING

KG MACHINE TOOLS

SAVE time · money · space

And at the same time be assured of a high rate of output to extremely fine limits with the installation of

EXTERNAL GRINDING

KEIGHLEY KU FULLY UNIVERSAL GRINDERS

TAPER GRINDING

KEIGHLEY KU 18" x 72" (HEAVY DUTY) GRINDER

22 MODELS AVAILABLE

CAPACITIES FROM 12" x 24" TO 24" x 96"

SIZE RANGE

STANDARD
12" x 24" to 12" x 60"

MEDIUM HEAVY
16" x 24" to 16" x 60"

HEAVY DUTY
18" x 24" to 18" x 96"
24" x 24" to 24" x 96"

ONE OF THE NEWALL GROUP

BROCHURES AND FURTHER DETAILS SENT ON REQUEST

NEWALL GROUP SALES LTD PETERBOROUGH · TEL: PETERBOROUGH 3227-8-9 AND KEIGHLEY 4294

Raising the standard of

Lighting

8ft

Fluorescent Tubular lamps

METROVICK

8 ft 125 watts

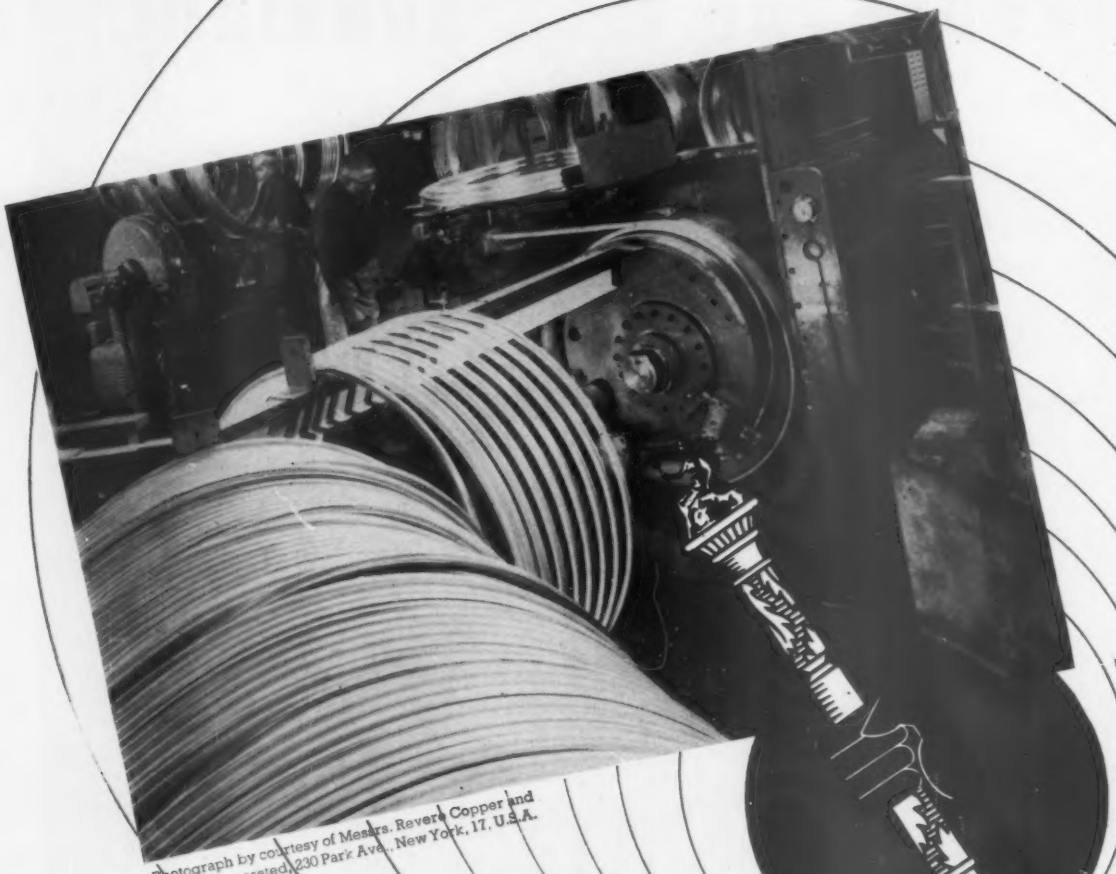
FLUORESCENT LAMPS

METROPOLITAN-VICKERS ELECTRICAL COMPANY LTD., St. Paul's Corner, 1-3 St. Paul's Churchyard, London, E.C.4.

Member of the A.E.I. Group of Companies.

S.A. 402

room for improvement
one to lift
and one to carr
THERE is always room for improvement and members of the "L.B." Productivity Team ensure that the price of goods is not boosted by costly man-handling. Stack to the ceiling—use every cubic foot of room with the LANSING BAGNALL Fork Truck, and when Pallet loads have to go to ground, shift them quickly with the P.P. 230 Pallet Truck. There is no quicker, safer or more economical way of handling goods than by "Mechanised Muscle."
Write and tell us of your present methods and we will show you YOUR room for improvement and how to draw profits out of the thin air among the highest stanchions of your factory.
Originators of "MECHANISED MUSCLE"
Lansing Bagnall
• BASINGSTOKE • HAMPSHIRE •
Telephone - 1010



Photograph by courtesy of Messrs. Revere Copper and Brass Incorporated, 230 Park Ave., New York, 17, U.S.A.

MARSHALL RICHARDS

ALUMINIUM TUBE IN BALTIMORE

One of the Marshall Richards Horizontal Tube Blocks in Revere's Baltimore, Md., Plant.

Installations like this allow us to accumulate the special knowledge which enables us to invite you to DRAW ON OUR EXPERIENCE.

MARSHALL RICHARDS MACHINE CO LIMITED

A MEMBER OF THE MARSHALL ORGANISATION

CROOK CO. DURHAM PHONE CROOK 272

M.R.100

Oiling the wheels of industry—

GLASS WORKING

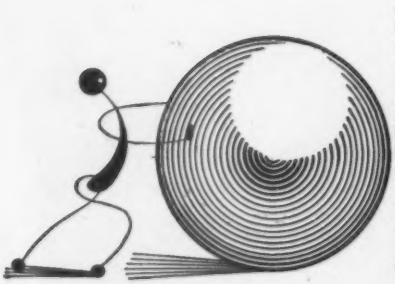
For every modern industrial process there is a specialised grade of Sea Shell Lubricant.

SHELL **leadership in lubrication**

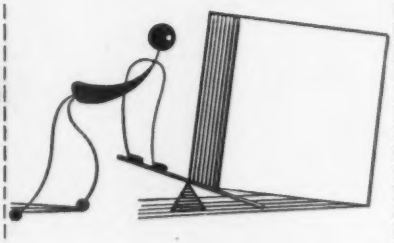
Copies of this advertisement in colour can be obtained from Shell-Mex and B.P. Ltd.

Hymatic Automation

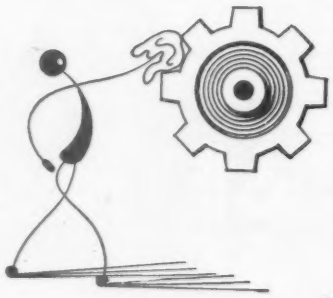
IS THE NAME FOR MACHINES THAT



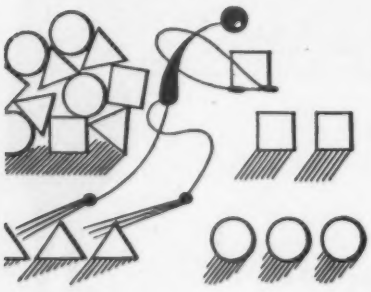
...roll...



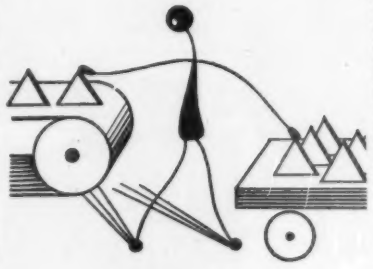
...dislodge...



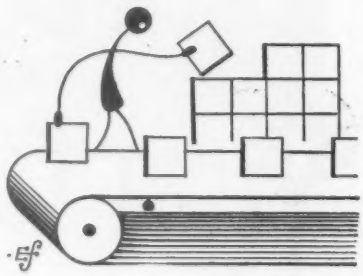
...clean...



...sort...



...shelve...



...feed parts

. . . reach, grasp, carry, lift, turn, clamp and tilt. Hymatic Automation is thus invaluable in the automatic and selective transfer of parts from one process to the next, from conveyor to conveyor; in unloading one machine and loading the next; or in quick clamping to hold parts during machining. All designs of Hymatic Automation are made for specific tasks, but are readily adaptable to others. Most of the designs are for Compressed Air working, because its cost is low. Air equipment is easy to maintain, quick and flexible in use, responds promptly to limit-switch control, and is reliable. Designs are simple and robust.

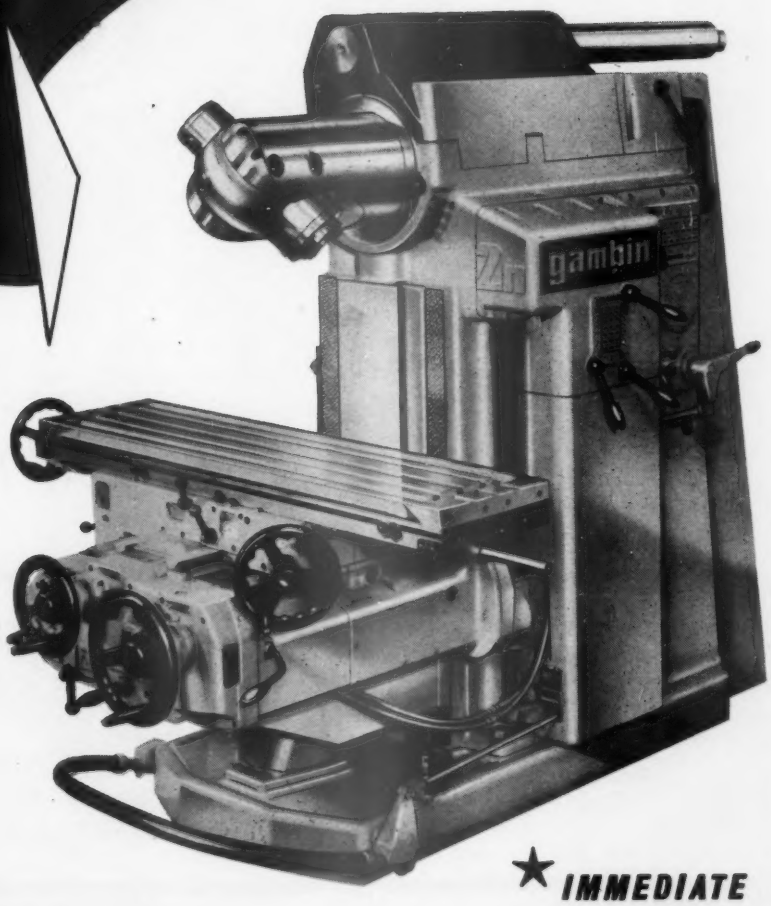
Perhaps in your works there are jobs where it is possible for people to burn or cut themselves; strain or crush themselves; lose fingers or even a hand; or perhaps there are jobs for which you just cannot find people. If so, we have reason to think that you *must* be interested in Hymatic Automation, and we would like you to get in touch with us with a view to discussing *your* especial problem.

Hymatic Automation

THE HYMATIC ENGINEERING CO. LTD. DEPT. HA.84 · REDDITCH · WORCS.

NEW! gambin Universal SWIVEL-HEAD MILLING MACHINE

Type 2n



- All-purpose.
- Available with slotting and high-speed drilling attachments, also with milling head for rack cutting, etc.
- Wide range of angular adjustments.
- 18 spindle speeds, from 20 to 1,000 r.p.m.
- 18 feeds from 0.4 to 20 in. per min. longitudinally and transversely, and 0.2 to 25 in. per min. vertically.

★ **IMMEDIATE DELIVERY**

★ **Write or telephone for full details or a demonstration.**

Sole Selling Agents in Gt. Britain and N. Ireland:

THE 600 GROUP OF COMPANIES

GEORGE COHEN SONS AND COMPANY LIMITED

SUNBEAM ROAD, LONDON, N.W.10. Telephone: Elgar 7222/7 · **STANNINGLEY, Nr. LEEDS.** Telephone: Pudsey 2241

And at Kingsbury (Nr. Tamworth) · **Manchester** · Glasgow · Swansea · Newcastle-on-Tyne · Belfast · Sheffield · Southampton · Bath

JIPE/552/MT98

it is no gamble

with a hand like this!

we are licensed by the British Standards Institution to use the Kite Mark which certifies that Zinc Alloy Diecastings conform with the requirements of British Standard 1004

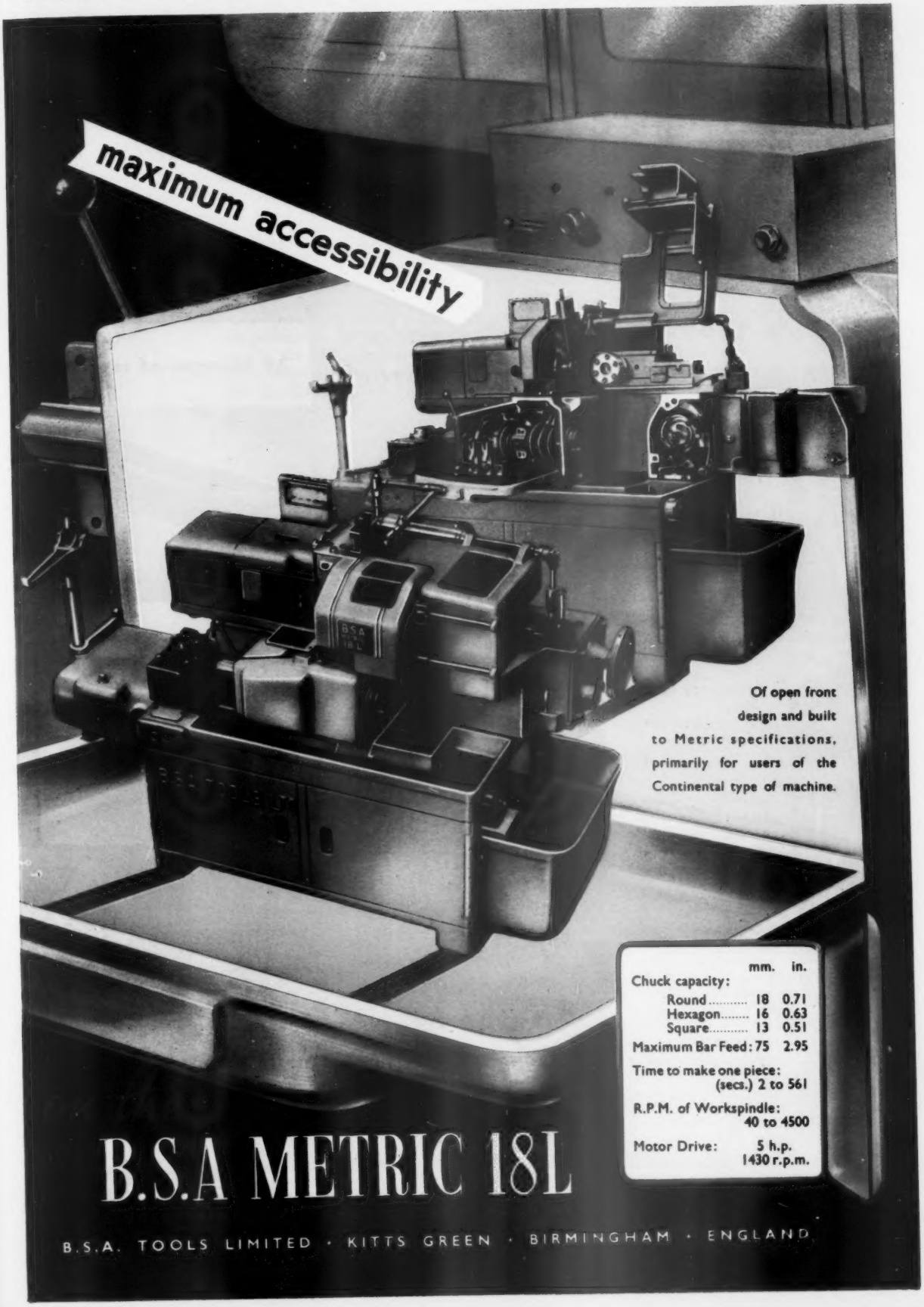
in addition to B.S.I. control of zinc alloy diecastings produced by us—all our production in other metals is subjected to strict quality control by our own Metallurgical Laboratory

the high standards we have imposed cost you no more

DYSON & CO., ENFIELD (1919), LTD.

SOUTHBURY WORKS · PONDERS END · MIDDLESEX

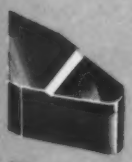
TEL: HOWARD 1484


maximum accessibility
Of open front design and built to Metric specifications, primarily for users of the Continental type of machine.
mm. in.
Chuck capacity:
Round..... 18 0.71
Hexagon..... 16 0.63
Square..... 13 0.51
Maximum Bar Feed: 75 2.95
Time to make one piece: (secs.) 2 to 561
R.P.M. of Workspindle: 40 to 4500
Motor Drive: 5 h.p. 1430 r.p.m.
B.S.A METRIC 18L
B.S.A. TOOLS LIMITED · KITTS GREEN · BIRMINGHAM · ENGLAND

Wimet – Britain's first carbide tools

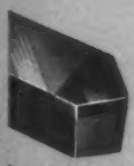
Way back in 1927 Wickman introduced carbide tools to this country. Since that time their use has spread so widely among the metal-working industries that to-day the name 'Wimet' has become synonymous with carbide tools and the higher productivity they bring. And with good reason; they cut faster, last longer, maintain accuracy and reduce tooling costs.

Here's today's range of standard turning tools available from stock



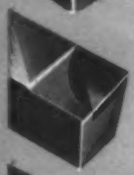
STRAIGHT ROUND NOSE TURNING TOOLS
For light-duty turning work, boring, chamfering, or profile turning.

CRANKED ROUND NOSE TURNING TOOLS
For light cuts, plain turning and facing.

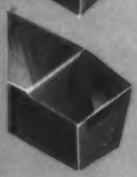


TURNING OR BORING TOOLS
For light-duty turning and boring.

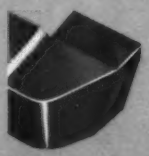
HEAVY-DUTY TURNING AND FACING TOOLS
For very heavy turning, boring and facing operations.



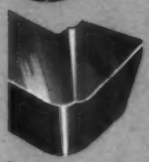
BAR TURNING TOOLS
For plain turning to square shoulders, recessing and counter boring.



BAR TURNING TOOLS
Suitable for use in knee holders.
For bar roughing, heavy boring and heavy turning, facing, etc.

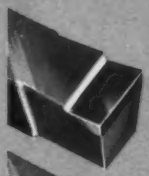


CRANKED KNIFE TOOLS
For broad facing cuts or similar operations.



CRANKED TURNING TOOLS
For light-duty turning and facing, boring and turning to square shoulders, etc.

CRANKED TURNING AND FACING TOOLS
For heavy-duty plain turning, facing, chamfering, boring, etc.

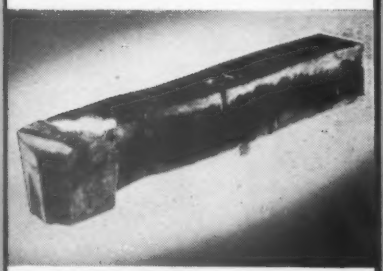


RECESSING TOOLS
For plunge cut recessing with light feeds and heavy-duty parting off.

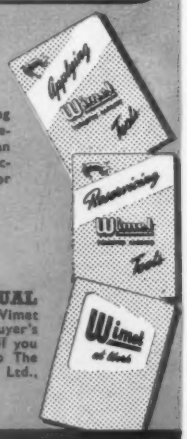
PARTING TOOLS
Made in two types; one for high cutting pressures, the other for light duty on all materials.

CLAMPTIP TOOLS
Available with round, triangular or square inserts.

An unsurpassed record!



The very first Wickman carbide tool was supplied to Armstrong Siddeley Motors Ltd., in August 1927. This tool remained in regular service until March, 1932. Four-and-a-half year's use from a single tool.



3 small books dealing with the application and re-servicing of carbide tools can help operators and production engineers. Write for copies now.

THE WIMET MANUAL contains full details of all Wimet Standard Tools—it's the buyer's guide for carbide tools. If you use carbide tools write to The Publicity Dept., Wickman Ltd., for a copy.

WICKMAN *of* COVENTRY

WICKMAN LIMITED, WIMET DIVISION, TORRINGTON AVENUE
COVENTRY, ENGLAND. *Telephone: Tile Hill 66621*

Wickman

3405T

The Institution of Production Engineers Journal
VOL. 34 NO. 3 MARCH, 1955

Education and Research for Production

Professor E. J. Richards, M.A., B.Sc., Professor of Aeronautical Engineering at the University of Southampton, develops the theme of the present series of leading articles and analyses the impact and findings of the Third Conference on "Problems of Aircraft Production", recently held at Southampton.

NOW that the third Aircraft Production Conference (organised by the Southern Section of the Institution and held in the University of Southampton) is over, the time is ripe to analyse the impact of this unique annual Conference on production thoughts in general. That the impact is great is undoubted, since it is one of the only too few occasions when production people come together to discuss their problems and hear from designers the likely trends for the future. On occasion, the Conference has raised a not inconsiderable stir in the daily press, perhaps unfortunate politically, but technically to the eventual advantage of production methods in this country.

As a layman at the Conference it is only possible for me to survey the scene in a general way, an approach which may not appeal to the hard-headed production man. Indeed, this difference in outlook has been one of the noticeable features of the last three conferences. Today design has, of necessity, been split up into specialist functional units, each having its basic principles and each section its own experts examining trends in terms of these principles. Thus a Chief Designer has at his disposal sufficient expert advice to allow him to generalise experience in any particular field, and to compare this experience with that of others. Design conferences, therefore, tend to discuss things in general terms and help greatly to direct general policy in the most forward direction. Production engineers in the aircraft industry, on the other hand, can call on very little expert help and their discussions are usually more detailed and far less easily used to direct general policy. For this reason it was a wise move on the part of the organisers to adopt as a theme for this year's Conference: "Integral Construction contrasted with Traditional Methods".

Education for Production

To some extent, the essential difference between the outlook of the designer and of the production engineer is one of training and education. For instance, the production man is still mainly recruited through trade apprenticeships with a technical college background, whereas the designer comes mainly through the Universities. It is a pity that the form of education with which the student begins tends to canalise the type of work which he takes up later. It would be better if both production and design recruited a proportion through a joint apprenticeship—University training. Indeed, the topic of "Education for Production" is so vital to the success of our future that I look forward in the years ahead to its being the "theme" of a whole Conference.

The really important thing which emerged from this year's Conference had little relation to the main theme of the Conference, "Integral Construction", but rather emphasised a factor which is becoming more and more apparent every year, viz: that we are rapidly getting to a position where we cannot hope, with existing organisations, to develop the prototypes which we attempt to produce. As Sir Edward Boyle stated, "the problem is much more one of development than of production".

The Immensity of the Task

The immensity of the task, and the foolishness of carrying on as we are doing, was emphasised by some of the figures given by Mr. Woodward-Nutt in his introductory Paper. A current British fighter, for example, involves some 12,000-15,000 production drawings and about 45,000 loft plates. Even with optimistic assumptions, this implies work of over four or five hundred draughtsmen's man-years on one design. This is a task well outside the capacity of any but the largest firms, except by a delayed programme which guarantees the obsolesence of the

aircraft long before it is in operation. This increase in complexity is reflected in every corner of the aircraft organisation; the manufacturing task is extended in commensurate fashion; the aerodynamic, stressing, flight testing, electrical and electronic programme of necessity being increased beyond all measure by the ever-extending range of flying speeds. Furthermore, the design teams in some of the aircraft firms are falling over backwards in attempting to produce sufficient work to fill the shops. As Mr. Petter stated in his excellent survey of the future: "Technical over-commitment is one of the scourges of our profession".

What are we to do about it? Certainly there appears no possibility of spending more money and manpower to speed up design and development; and the conclusion drawn by Mr. Woodward-Nutt, that military aircraft in future are more likely to be ordered in tens than in hundreds or thousands, can only reduce the production efficiency of those firms making aircraft, and extend still further the "falling-over backwards" antics of the design teams. Evidence exists already that an increase in the number of prototypes ordered of each kind would make a significant improvement in development time and cost.

One approach to the problem lies in the simplification of our aircraft or the provision of cheaper second-line aircraft for peacetime training. While the amount that can be done along these lines cannot be very great, we cannot afford to ignore any such aircraft, particularly when their limitations cannot be assessed except in operations.

Fewer Types to be Ordered

The real answer must lie in the ordering of fewer types, with far less "second string" types in case the first string goes wrong. This must also be accompanied by a bolder policy of prototype ordering and by larger production orders than can otherwise be envisaged with the existing capacity of the national purse. This would allow a more reasonable tempo in the design offices and less likelihood of the large development delays now prevalent. As Mr. Petter said, "Less new endeavours, fully and lovingly completed, would certainly ensure more, not fewer, production successes".

What then of the unsuccessful firms, left without an aeroplane to manufacture? A note of considerable significance in this matter was sounded by Mr. Woodward-Nutt, who remarked that the total expenditure on aircraft in the U.S.A. was some twenty times that in this country, whereas the number of firms was the same. Thus, allowing for the difference in money values, the average firm in the United States must be of the order of four or five times the size of firms in this country. Further, the number of prototypes produced is not significantly larger than that in this country.

To some extent, therefore, good will come from some degree of amalgamation: many small firms have, however, shown such excellent management and initiative that, all in all, only harm and inefficiency would come from wholesale amalgamation. It is not apparent that the largeness of American aircraft firms has increased their efficiency, except possibly in aircraft performance development.

Specialist Firms

If the aircraft firms are not to build complete aircraft, what then can they do? A possible solution, which is put forward here as a talking point, lies in a system of increasing specialisation and subcontracting. For example, some firms, weak on the general design side, should be encouraged to take up wing design and manufacture as a specialist feature. If these firms are given by the Government a large amount of research and development work which would allow their becoming sufficiently advanced in their techniques, manufacturing methods such as skin milling and integral construction could be evolved which would be beyond the capacity of the normal airframe designers.

This particular example of specialisation is well worth dwelling on for a moment. In his spoken lecture at Southampton, Mr. Keen struck a very real note when he commented that one of the depressing features of the work on structural methods was the inability of the large design firms to use the methods evolved through lack of "know-how", and the danger of tackling a new problem in the small time allotted to the tasks; the firms given the structural methods contract, in turn, were unable to benefit from the work owing to their not having an aircraft design programme. This lack of liaison between research and development is undoubtedly wasteful, and could be eliminated by the acceptance by main contractors and the

enforcement by the Ministry of Supply of the principle that their wings are designed and made for them by specialist designers, specially designed methods and special machine tools.

Such firms could happily take over the whole procedure of wing design and stressing and would by the very nature of their specialisation contribute much more fully to development of new methods, fatigue preventatives and the like. In this way, and in this way only, can the conflicting wing requirements of the future be met. The compromise between cheapness, strength, thinness, freedom from fatigue and the need for the greatest amount of internal space for fuel, especially in the coming age of supersonic aircraft, requires a specialist team of designers and producers who are constantly concerned with this field.

Location of Specialist Machine Tools

This approach to the problem would also help enormously the assignment of large and expensive machine tools, difficult to justify in each firm at the moment, with the numbers of aircraft produced. It can well be argued that the larger and more expensive the machine tool, the more reason there is to locate it with a specialist firm whose type of work requires its constant utilisation. In the example given here of specialist wing firms, much better use would be made of complicated skin millers and profiling machines. As Mr. Woodward-Nutt states, " because we cannot afford to build the very expensive and complicated aircraft of the future in very large quantities, any costly plant and tools involved should be capable of handling the components of a series of designs ".

No doubt the question of vulnerability will be raised as an objection to further specialisation. Clearly this needs to be carefully considered, but it is by no means obvious that such a step would increase vulnerabilty appreciably. The real need is for the best peacetime deployment of our design and production effort to ensure the greatest production of satisfactory aircraft.

Many will point out the difficulties of wing design away from the parent firm, with the problems of engine installation, undercarriage cut-outs, fuel tanks and the like. Since our purpose is to spread efficiently the design effort in a single aeroplane over more than one firm, this must be accepted as the major danger and suitable liaison arranged. It may well be, however, that the example I have chosen is not the most suitable one; other possibilities that come to mind are cabin or cockpit design, and fin and tail assembly design. The number of suitable cases is small, but needs careful thought. On the other hand, when it is realised that some of the firms dabble in aircraft, guided missiles and helicopter production, the scope for tailoring the effort is much greater than might at first appear.

Construction under Licence

The remarkable thing about design and development in this country is not the muddle apparent at the present time, but rather the progress we have achieved with a fraction of the manpower available elsewhere. Indeed, it must never be forgotten that we are selling engines and airliners abroad in a quite unprecedented way. We must, therefore, ask ourselves : " Is the cutting back of our second string policy, advocated above, sufficient to put our house in order "? For the purpose of defence and trade, we must still have a wealth of types produced in this country, including long range and medium range airliners, all-weather and specialist fighters, attack aircraft, guided missiles, and helicopters. All these need to be designed, and the necessary research carried out. There is, therefore, very little sign of unemployment. On the contrary, it is unlikely that the redeployment advocated above will be enough to ease the burden of our designers' efforts. It is to be wondered, therefore, whether in some fields where our needs do not differ greatly from the U.S.A., and where last minute progress need not be incorporated, more use should not be made of manufacture under licence. This thought, and it is only a thought, finds difficulty of acceptance, but is nevertheless sensible. If such an idea were extended, our small design teams would obtain more time for development work—a great lack in our existing organisations. Which aeroplanes we should obtain in this way is open to question, possibly *ab initio* trainers, seaplanes or helicopters. It is not necessary to go into it further here.

What is certain may be expressed in Mr. Petter's words at the Southampton Conference—we need to " find how to canalise the work of our limited research, designing and development manpower through the right channels in order that we may have a certain number of producible aeroplanes ".

Third Conference on

"PROBLEMS OF AIRCRAFT PRODUCTION"

Southampton, 14th/15th January, 1955

Theme : "Integral construction contrasted with traditional methods"

The third Conference on "Problems of Aircraft Production", organised by the Southern Section of the Institution, took place on 14th/15th January, 1955, at the University of Southampton, by kind permission of the Vice-Chancellor. The full programme is given below.

The first two Sessions of the Conference are reported in this issue of the Journal. Sessions III and IV will be reported in the April issue.

SESSION I

"AIRCRAFT DESIGN PROBLEMS AND TRENDS"

Speaker : A. E. WOODWARD-NUTT, M.A., F.R.Ae.S., Principal Director of Research and Development (Aircraft), Ministry of Supply.

Chairman: Air Marshal SIR HUGH WALMSLEY, K.C.B., C.B.E., M.C., D.F.C., Managing Director, Air Service Training, Ltd.

Luncheon

Speakers : Alderman R. E. EDMUNDS, Mayor of Southampton.

SIR EDWARD BOYLE, Bt. M.P., Parliamentary Secretary, Ministry of Supply.

Chairman: F. T. WEST, M.B.E., M.I.Prod.E., A.I.Struct.E., M.R.San.I., Chairman, Southampton Section, and Principal, Southampton Technical College.

SESSION II

(i) "PROBLEMS OF FORGING"

Speaker : G. W. RICHARDS, Director, High Duty Alloys, Ltd

(ii) "MACHINING AND FORMING PROBLEMS OF INTEGRAL CONSTRUCTION"

Speakers : E. D. KEEN, B.Sc., F.R.Ae.S., Assistant Chief Designer, Sir W. G. Armstrong Whitworth Aircraft, Ltd.

A. MENZIES, Process Development Manager, Sir W. G. Armstrong Whitworth Aircraft, Ltd.

Chairman: R. S. BROWN, M.I.Prod.E., General Manager (Aircraft), Aircraft Division, Bristol Aeroplane Company, Ltd.

SESSION III

"HIGH SPEED MACHINE TOOLS FOR AIRCRAFT PRODUCTION"

Speaker : S. RADCLIFFE, B.Sc.(Tech.), A.M.I.Mech.E., M.I.Prod.E., Technical Director, Wadkin, Ltd. (representing Machine Tool Trades Association).

Chairman: F. C. COOKE, M.I.Prod.E., General Production Manager, Field Aircraft Services, Ltd.

SESSION IV

"WHERE DO WE GO FROM HERE?"

Speaker : W. E. W. PETTER, C.B.E., B.A., F.R.Ae.S., Managing Director and Chief Engineer, Folland Aircraft, Ltd.

Chairman: F. T. WEST, M.B.E., M.I.Prod.E., A.I.Struct.E., M.R.San.I.

AIRCRAFT DESIGN PROBLEMS AND TRENDS

by A. E. WOODWARD-NUTT, M.A., F.R.Ae.S.

Mr. Woodward-Nutt is Principal Director of Research and Development (Aircraft) at the Ministry of Supply.

After taking an Honours Degree in Engineering at Cambridge, where he was Seely Prizeman in aeronautics, he has spent over 30 years in aviation, mostly in Government service. After a year with de Havilland's he joined the Air Ministry and spent some 13 years at the Experimental Establishments at Farnborough, Martlesham Heath and Felixstowe, mostly on aerodynamic research, full-scale flight testing and performance work. In 1938 he was put in charge of a Headquarters branch dealing with defence against air attack, and in 1941 he was made Assistant Director responsible for bomber development.

In 1945 he was made Deputy Director in charge of civil aircraft development, becoming Director in 1947. In 1950 he became Director of Military Aircraft Research and Development, and was appointed to his present post in June, 1952.

He has been a Fellow of the Royal Aeronautical Society since 1945.

Mr. Woodward-Nutt

MY task today is to talk to you about the trends in the design of aircraft and the problems which these trends present, both to the designer himself and to the production engineer who is responsible for making the finished article. Before an audience including so many who are both experienced and distinguished in the practical design or production of aircraft, I am very conscious of my own lack of practical experience in either of these fields. It is always so easy for the man on the sidelines, or the one sitting in a Ministry chair, to think he can do things better than the man actually playing the game or getting on with the job. I hope you will accept my assurance that I have no feelings of this kind and that my comments today merely stem from impressions formed by one who is able to take a wide, if somewhat superficial, view of the whole field.

The theme running through this Conference is a comparison of integral and conventional methods of construction for aircraft. I might as well warn you at the outset that I am not going to come down heavily in favour of either method. That is a problem on which you designers and production engineers have to decide for yourselves. I intend to adopt a masterly, sitting-on-the-fence attitude, as no doubt you are expecting from a dyed-in-the-wool Civil Servant. I cannot but be aware, however, that there has been recently a trend towards greater integration in aircraft construction, and I feel that this trend must continue to some extent, in much the same way as must the trend in the military aircraft field for greater integration between the aircraft itself and its equipment. The difficult part is to decide how far it should go.

Comparisons with U.S. Practice

In looking at problems of this kind I find frequently a tendency to ask what is being done in the U.S.A.

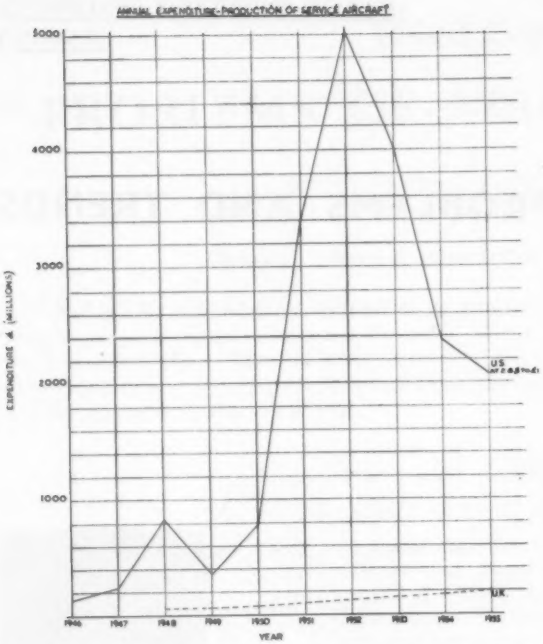


Fig. 1. Expenditure on military aircraft in the U.S.A. and U.K. since 1946.

and to conclude that anything done there must be right. This is a conclusion with which I heartily disagree. Whilst I yield to none in my admiration of the skill, vigour and enterprise of American engineers in general, and American aeronautical engineers in particular, and appreciate that there is much that we can learn from them, I have in mind that not only are the problems which they have to solve often quite different from ours, but the resources which they can bring to bear on them are also vastly different. I should like to enlarge on that for a few moments. Taking the military field first, the tactical and strategical problems of defending a vast continent situated some thousands of miles from a potential aggressor are very different from those of defending two small islands like the United Kingdom, situated a few hundred miles only from possible enemy bases. Similarly for offensive aircraft. Bombers starting from this country can expect to be over hostile territory after flying a few hundred miles, whereas those starting from the U.S.A. may be able to traverse some thousands of miles of ocean or friendly territory before coming under enemy fire. These are but two of the many factors which influence profoundly the trend of military aircraft design in the two countries. In the civil field there are similar differences, although they are perhaps not so immediately apparent. The main factor which influences American policy here is the existence of a very large domestic market right on the manufacturers' doorstep, whereas the British manufacturer is largely dependent on the foreign orders which he can obtain.

As regards the difference in resources, Fig. 1 compares the expenditure on military aircraft in the U.S.A. and U.K. over the last few years. My only comment is that the number of major aircraft manufacturers is approximately the same in each country.

Changes in Methods of Construction

I now propose to sketch briefly the main changes which have occurred in the methods of construction of aircraft in this country during the last fifty years.

In the 1910's the structure was built of wood, with steel joints, braced with steel wire, and covered with fabric. The aircraft were either biplanes or braced monoplanes. A few, late in the decade, had wooden monocoque fuselages, which could be regarded as a form of integral construction. In the 1920's came the cantilever monoplane, and the substitution of metal, in the form of steel or light alloy, for the main structural members such as the main spars and fuselage longerons, while the wire bracing and fabric coverings were still retained in most cases. About 1926 the historic decision was made that all future aircraft for the Royal Air Force should be made of metal. It was during the 1930's that we had the first British aircraft with stressed skin light alloy covered wings, but we also had the complicated thin steel structures developed by Armstrong Whitworth, and later Wallis' geodetic construction, both with fabric coverings and both employing numerous small parts and rivets. In the 1940's there was a gradual change from the old two-spar thin-skinned wing to the thicker skins and multi-spar or torsion box structures which persist to-day. A similar change occurred with fuselages, the internal bracing being eliminated and the requisite stiffness in bending and torsion being provided by light alloy frames and

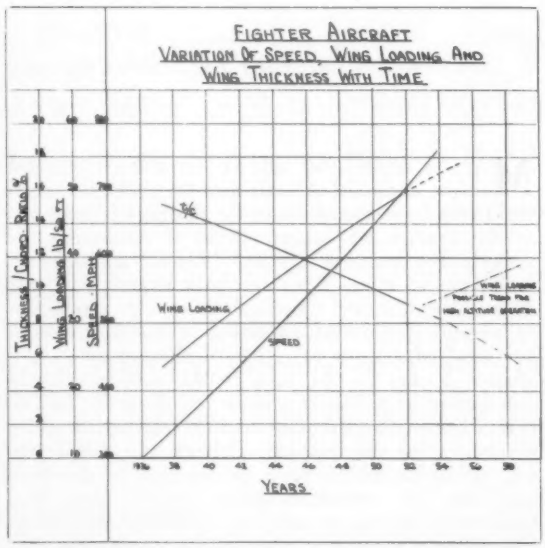


Fig. 2. Variation in fighter wing thickness, loading and speed, with time.

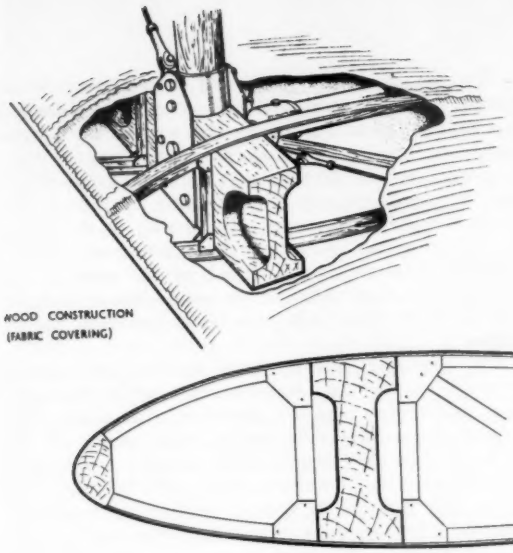


Fig. 3.

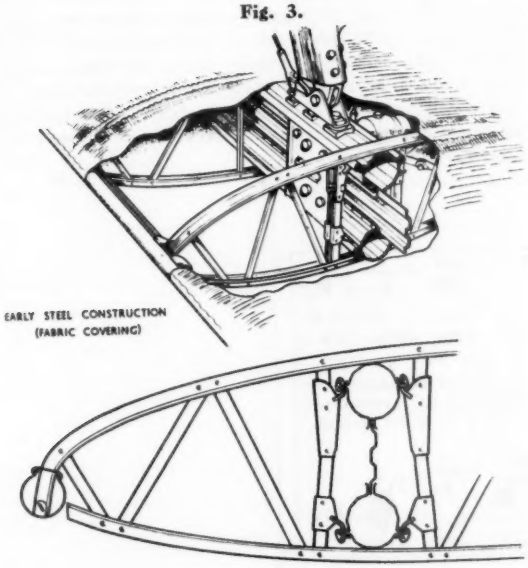


Fig. 4.

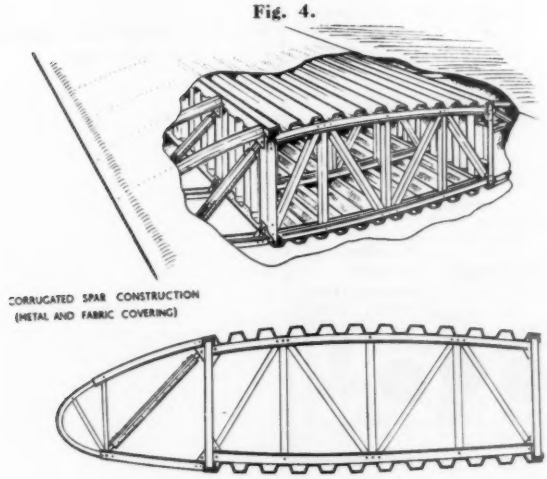
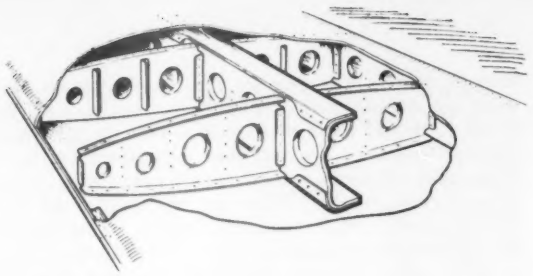


Fig. 5.



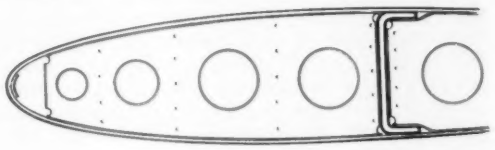


Fig. 6.

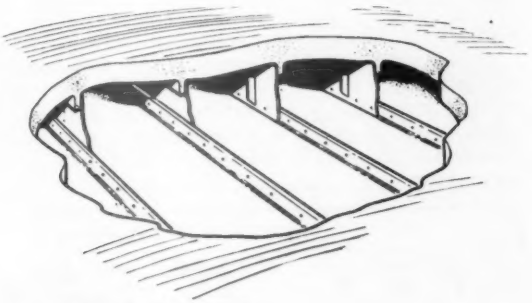


Fig. 7.

Typical forms of wing construction

Fig. 3. Wood and fabric.

Fig. 4. Metal and fabric.

Fig. 5. Corrugated metal

Fig. 6. Stressed skin.

Fig. 7. Integral construction.

stressed skins. The reasons for these changes have been the steadily increasing flight loads, and the desire to spread these more evenly over the wing and fuselage surfaces. The increases in performance have demanded thinner, smoother and eventually swept wings. Now, in the 1950's, the tendency is for still thinner wings, with relatively thicker skins, which lend themselves to more integrated construction. The trend in wing loading and thickness over the last 20 years is indicated in Fig. 2.

So far as materials are concerned, I think it is true that something like 80% of most of the aircraft of to-day are made of aluminium alloy, and more than half of this is usually sheet or strip; so we have not got very far in integration yet. What I have been saying is illustrated in Figs. 3-7, which have kindly been supplied by Armstrong Whitworth Aircraft. They show typical forms of wing construction, rangeing from wood and fabric to an integrated light alloy wing.

Growth of Complexity

I have indicated, very sketchily, how the methods of construction of aircraft have changed, and I now want to relate this to the other changes which have taken place, in order to emphasise the increase in complexity of aircraft designed to do basically the same thing

The diagrams in Figs. 8 and 9 indicate how the weight, power, speed and ceiling of a hypothetical but typical fighter, and how the weight, power and range of a bomber have increased over some 40 years. You will see, for example, that the weight of a fighter has increased roughly twenty times and that of a bomber roughly ten times. In passing, it is interesting to speculate whether the advent of nuclear weapons will arrest this trend in the case of the bomber. Perhaps Mr. Petter would claim that the advent of the Gnat will have a similar effect on the fighter!

However you look at them, the military aircraft of to-day and of the immediate future are becoming large and highly complex pieces of machinery. This complexity is well reflected in their cost. At the start of the 1939 war fighter aircraft cost about £7,500 each, and bombers about £20,000. The cost of the day fighters in current production is not far short of £100,000 each, and that of the next generation of fighters is likely to be more than double that figure. The cost of bombers and military transports in current production is in the region of half a million pounds each. Future types are likely to exceed this figure considerably, as indeed do some of the types now being built in the U.S.A. Even allowing for the change in the value of money the increase in striking.

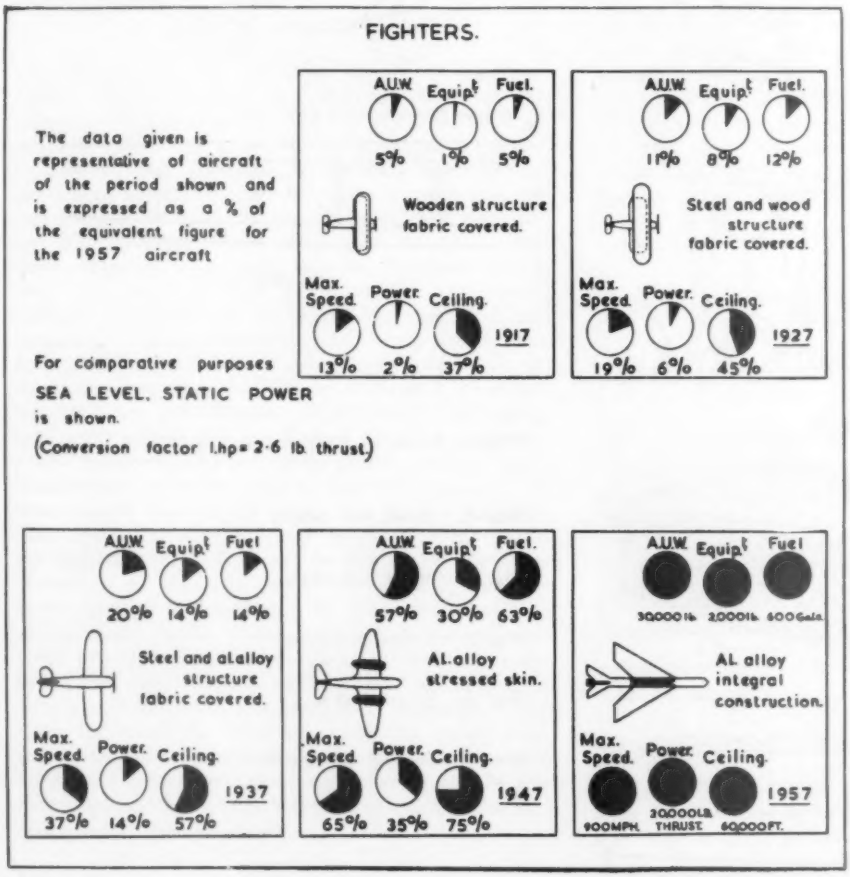


Fig. 8. Changes in fighters over 40 years.

I should like to give you a few more figures to illustrate the complexity of modern aircraft. These may be familiar to some of you, but I make no apology for quoting them since they serve to emphasise my point. Current British day fighters involve some 12-15,000 production drawings, and for one of the 'V' bombers about 20,000 production drawings and about 45,000 loft plates are required. The number of jigs and tools is about 135,000. Incidentally, these figures exclude the engines.

The Hampden bomber, built in the late 1930's, carried less than 150 lb. of radio and electrical equipment and its electrical power consumption was about 6 kilowatts. The electrical and radio equipment in a well known modern bomber weighs nearly 9000 lb., and the power consumption is in the region of 100 kilowatts. In future types this last figure may well be doubled.

In a current single-engined day fighter there are not far short of 250,000 rivets, and over 35,000 nuts, bolts and washers, which together account for a total weight of nearly 950 lb. In a light bomber the weight of these items is over 1,300 lb.

What conclusions can be drawn from figures of this kind? One, presumably, is that we must pursue any methods which will reduce the complexity and cost of modern aircraft, and here the potentialities of greater integration of the structure certainly deserve careful study.

Another conclusion which is inescapable is that with the enormous increase in the cost of aircraft, and the likelihood that the national economy will prevent any substantial increase in the amount of money available for the purchase of new aircraft and equipment for the Services, the numbers of aircraft ordered in the future must be far less than those to which we are accustomed. In other words, military aircraft in future are more likely to be ordered in tens than in hundreds or thousands. This has an obvious bearing on the amount of money which can reasonably be invested in capital equipment and tools for their manufacture.

Variety in Aircraft Design

To-day we seem to have a wider variety of shapes and sizes of aircraft than ever before. Having said that, I immediately wonder whether it is one of the things that has been said every year since 1903! Be that as it may, we have to-day a bewildering variety of types, and one may well ask in what direction we are going. Production engineers are as directly concerned with this as are designers, for

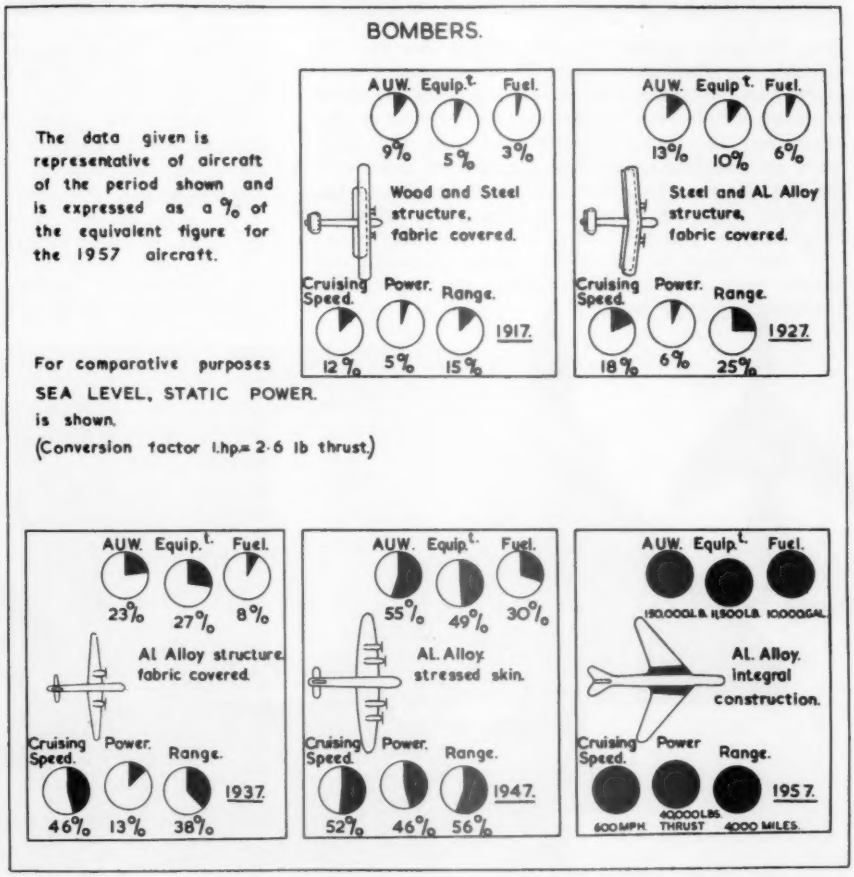

BOMBERS.
The data given is representative of aircraft of the period shown and is expressed as a % of the equivalent figure for the 1957 aircraft.
For comparative purposes SEA LEVEL, STATIC POWER. is shown.
(Conversion factor 1 h.p. = 2·6 lb thrust.)
AUW. Equip.t. Fuel.
9% 5% 3%
Wood and Steel structure, fabric covered.
Cruising Speed. Power. Range.
12% 5% 15%
1917.
AUW. Equip.t. Fuel.
13% 10% 6%
Steel and Al. Alloy structure, fabric covered.
Cruising Speed. Power. Range.
18% 6% 25%
1927.
AUW. Equip.t. Fuel.
23% 27% 8%
Al Alloy structure fabric covered.
Cruising Speed. Power. Range.
46% 13% 38%
1937.
AUW. Equip.t. Fuel.
55% 49% 30%
Al. Alloy stressed skin.
Cruising Speed. Power. Range.
52% 46% 56%
1947.
AUW. Equip.t. Fuel.
150,000 LBS. 11,500 LB. 10,000 GAL.
Al. Alloy. integral construction.
Cruising Speed. Power Range.
600 MPH. 40,000 LBS THRUST 4000 MILES.
1957.

Fig. 9. Changes in bombers over 40 years.

Fig. 10. Convair F 102.

since the total number required of any one type of aircraft is unlikely to be large, for the reasons I have given, they will want to know something of the types expected to follow it, so that they can decide on the magnitude of expenditure permissible on the basic tools such as forging presses, skin millers, etc., and can try to see that these are designed with the flexibility necessary to cover as large a total number of aircraft as possible. Here is yet another reason why there must be the closest liaison between designers and production engineers—no far-sighted planning is possible without it.

Looking first at fighters, the typical fighter in production to-day, such as the Hunter, Swift or Sabre, has wings with about 40° sweepback and with a thickness/chord ratio of 9-10% and cannot fly supersonically except in a dive. Closely following are delta winged aircraft with wings of rather less equivalent thickness, such as the Javelin and Convair F.102, (Fig. 10) and we also have the English Electric P.1. (Fig. 11), all with rather better performance. But we also have different concepts of fighters such as the MacDonnell Voodoo (Fig. 12) which is reported in the technical press as having two engines develop-

Fig. 11.
English Electric P.1.

Crown Copyright Reserved

Fig. 12.
McDonnell Voodoo.

ing 15,000 lb. thrust each and as weighing 40,000-50,000 lb. It is proudly claimed as the largest and heaviest fighter in the world! In contrast we have the Folland Gnat, potentially the smallest and lightest fighter in the world, which will mount two 30 m/m cannon, and the underpowered prototype of which has already flown supersonically, (Fig. 13). Fig. 14 shows the Gnat and the Javelin to the same scale.

Looking a little farther ahead, we can expect still thinner wings, possibly without sweepback, and still higher performance. About a year ago an American research aircraft flew at 1,650 m.p.h. at 90,000 ft. (M=2.5). The performance attained by the research aircraft of to-day is likely to be reached by the operational fighter of to-morrow—and whilst I am not going to be rash enough to prophesy when 'tomorrow' will be, it will not be the Spanish *mañana*.

Fig. 15 shows the Douglas X-3 research aircraft, and the shapes of some of these aircraft are shown in Fig. 16, on which the Hunter is drawn to the same scale. From these you will see that, like Father O'Flynn, "we can offer a charmin' variety".

Whilst the 'shape of wings to come' may still be somewhat problematical, one thing, however, is certain, and that is that at the higher speeds which we are now approaching the cooling problem is becoming acute. Already we are meeting difficult problems in cooling the equipment of fighters, and when we reach speeds of M=2 and above, the aerodynamic heating of the aircraft structure itself begins to affect the choice of materials for construction. Fig. 17 gives an indication of the effect of aerodynamic heating, and the limiting temperatures for certain well-known aluminium alloys used in aircraft construction. I do not want to

Fig. 13. Folland Midge.

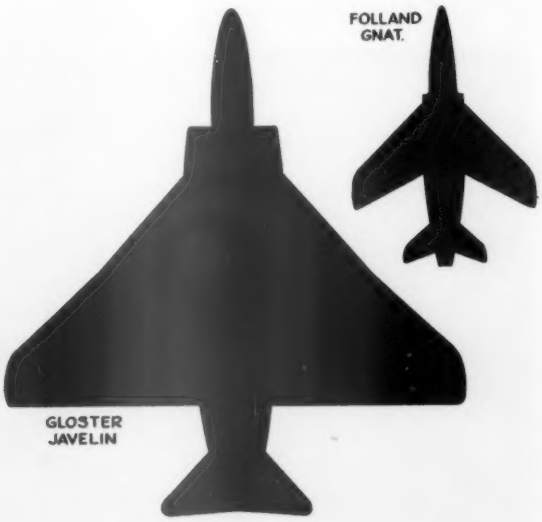


Fig. 14. Silhouettes of Gnat and Javelin.

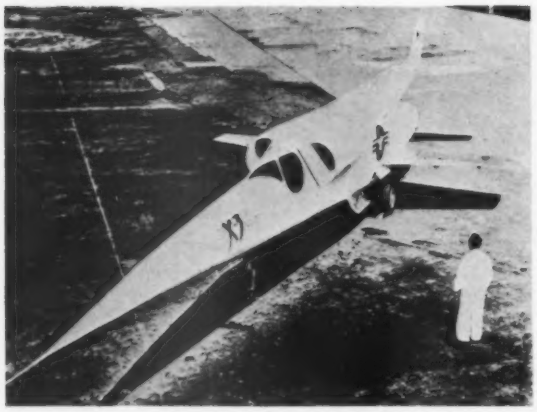


Fig. 15. Douglas X-3 research aircraft.

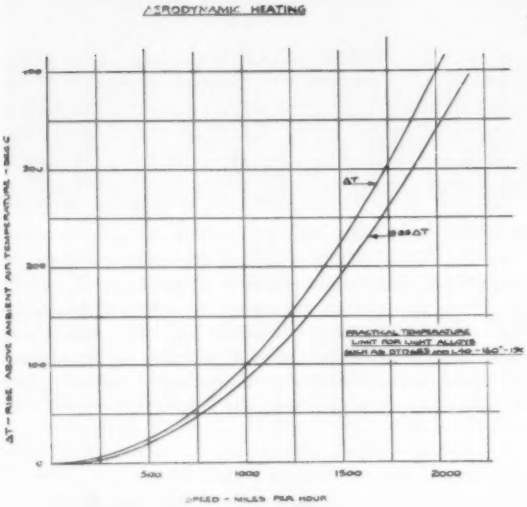


Fig. 17. (left) Curve of aerodynamic heating against speed.

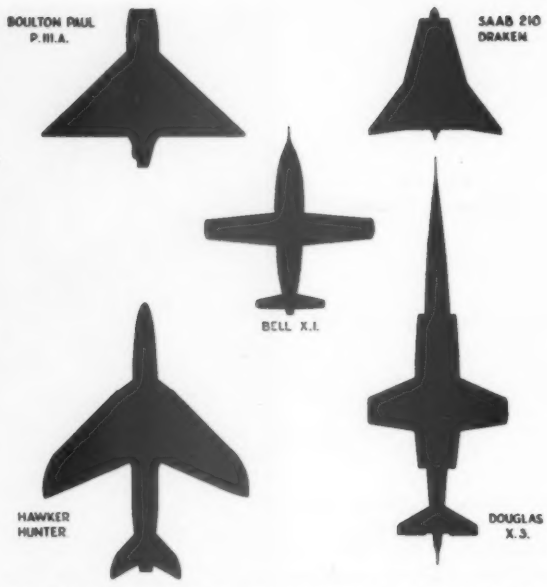


Fig. 16. Silhouettes of current fighter and research aircraft.

Fig. 18. Boeing B 52a bomber.

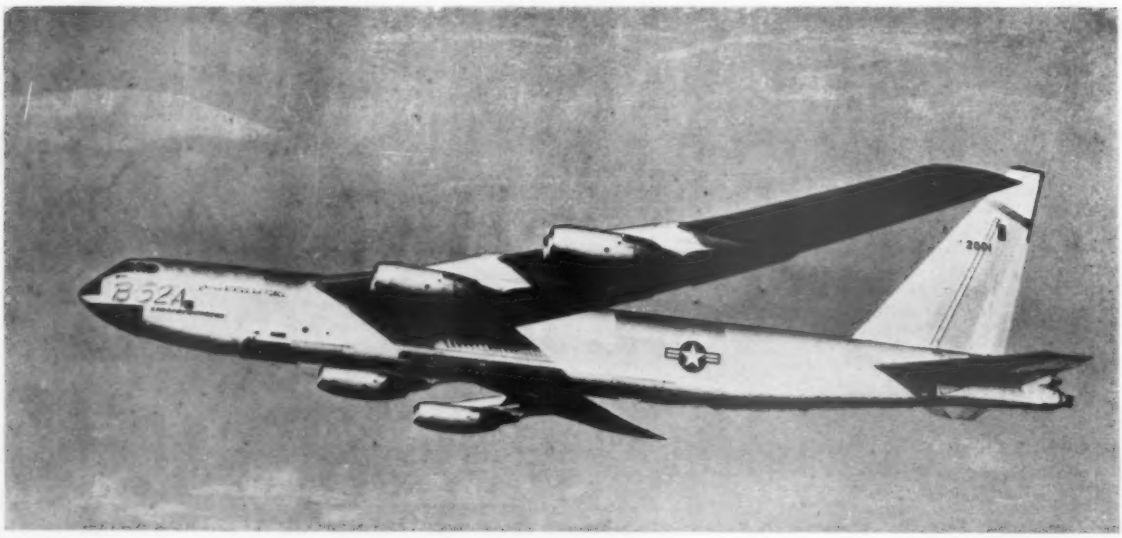


Fig. 19. Avro Vulcan.

elaborate the subject here, but simply to draw attention to the fact that for aircraft destined to fly for more than a few minutes at speeds above about M=2, much of the structure will have to be built of material other than aluminium alloys, or special arrangements devised for cooling the structure. Either will result in a radical change in constructional methods.

In passing I might add that steel seems to be the most likely material for the main structure of such aircraft for some time; titanium, I think, will be used more in engines and in parts of the aircraft other than the main structure.

With bombers we have less variety in shapes, the choice at present being between the moderately swept, high aspect ratio type such as the Boeing B.52 (Fig. 18) and the delta type exemplified by the Vulcan (Fig. 19), with the Valiant and the Victor

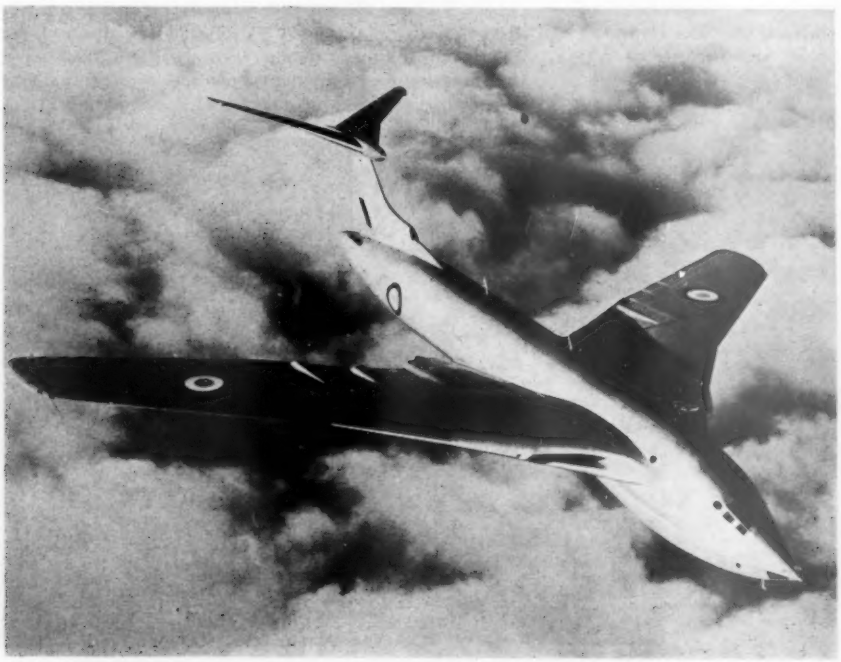


Fig. 20.
Handley Page Victor.

Fig. 21. Silhouettes of Vulcan and Boeing B 52.

(Fig. 20), with its crescent shaped wing, lying between. Fig. 21 shows silhouettes of the Vulcan and B.52 to the same scale.

The bomber of to-day cruises roughly twice as fast and twice as high as did the bombers at the end of the last war. It is reasonable to assume that the next generation of bombers will cruise even higher and faster, but I leave it to you to guess along which of these two lines, if either, it will go.

Transport aircraft, whether civil or military, differ less in their shapes. The emphasis here is on reliability and economy. Broadly, the turbo-prop seems to be slowly but surely replacing the piston-engined type on the shorter routes, but on the longer routes the battle between the turbo-jet and the turbo-prop has yet to be decided. Change here will be slower, however, and it is possible to plan ahead in manufacturing capacities without so much risk of being caught out by radical changes in design. Representative types of transport aircraft shortly coming into service are the Beverley, Britannia, Comet III, Boeing 707 and Vickers 1000 (Figs. 22-26).

Fig. 22. Blackburn Beverley.

In addition to these aircraft with fixed wings there is a wide variety of rotary winged aircraft under development, some gear driven, some tip driven, some with piston and some with turbine engines, and with varying numbers of rotors and of blades in them. The Bristol 173 (Fig. 27) is the most recent British helicopter to go into production.

There are other developments in the offing. Possibly the Convair XFY-I (Fig. 28) and the Rolls-Royce "Flying Bedstead" (Fig. 29) are forerunners of aircraft of quite a different kind. Some enthusiasts claim that in ten years or so many military aircraft will be replaced by pilotless guided vehicles of curious shapes and travelling at incredible speeds. Others promise us nuclear powered aircraft with almost unlimited endurance, again—according to no

Fig. 23. Bristol Britannia.

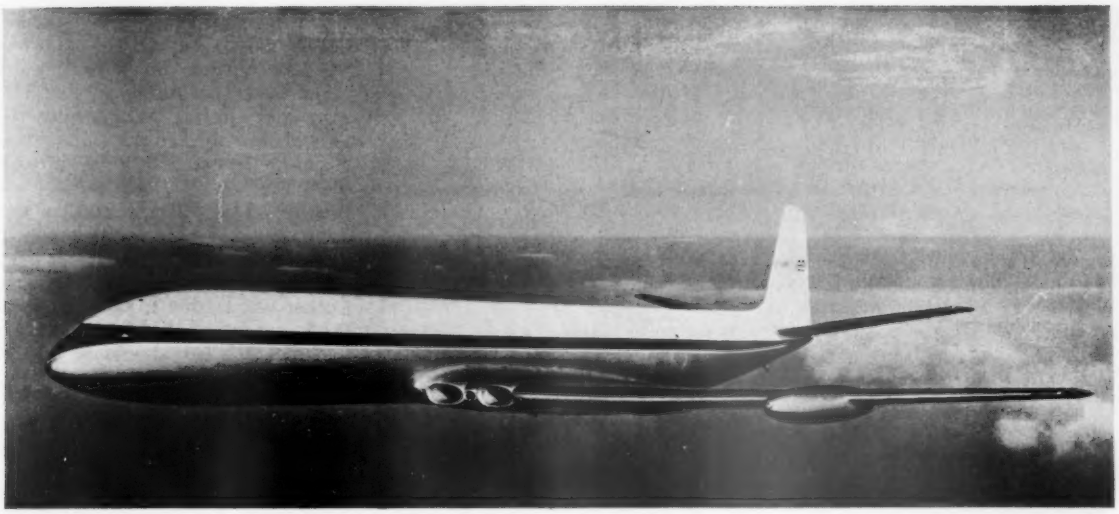


Fig. 24. de Havilland Comet III.

less an authority than Hall L. Hibberd of Lockheeds, —within that same ten years. In more remote fields, talk of flying saucers has given pride of place to electro-gravitics, whatever they may be.

A great deal of this may be unbalanced optimism or merely wishful thinking, but the point I want to make is that we are still in a stage of rapid advances in the art of aviation. Except in certain very limited fields we cannot yet count on steady and slow development, along well defined lines, enabling a clear view to be taken of what lies ten or twenty years ahead. On the contrary, I think we are likely to see quite drastic changes during at least the longer of these two periods, changes comparable with those which followed the advent of the gas turbine. This demands plans giving the greatest possible flexibility in the methods of construction of our aircraft.

Conventional or Integral Construction ?

As I have said, there has been a trend towards greater integration in constructional methods during the last few years. Military aircraft which have to fly at supersonic speeds must have thin, smooth and heavily loaded wings and control surfaces, and fuselages of the smallest possible cross-sectional area but with the greatest possible stowage space. All would agree that these requirements can best be met by some degree of integration in construction. With other types of aircraft the question seems more open. There are many who advocate a much more wholesale change-over, with the provision of more and larger forging and extrusion presses, skin millers, and so on. Others say that such equipment is far too expensive, and its use too limited to warrant the large capital expenditure involved.

I do not know which is right, but I am going to try to summarise some of the arguments I have heard on either side and will leave you to decide which are the most powerful. I will deal with the subject under various headings :-

(a) *Cost.* This is probably the most important and also the most controversial aspect. The argument most used in favour of integral construction is that the saving in design and manufacture of details, and in assembly time, greatly exceeds the increased cost in machining time and in scrap. Examples in support of this were quoted by Keith-Lucas and Woodley in lectures before your Conference here in 1953, and were quite striking. There are, however, one or two other factors which ought properly to be taken into account. There is the cost of the plant and machinery required both to produce the initial plates, forgings

Fig. 25. Boeing 707.

or extrusions and to process them. This is likely to be large for highly integrated units, and must be amortised over the number of components made; and we must remember that the number of aircraft likely to be made to any one design is decreasing. Then I suppose some allowance should be made for the possibility of errors at a late stage in a long machining cycle, involving the scrapping of large and costly parts on which many man-hours have been spent.

(b) *Weight.* I think all are agreed that integration in construction should lead to a reduction in weight because of the reduction in the number of joints and the ability to vary the thickness of skins more uniformly to suit the loading conditions. In wings, weight can also be saved in incorporating integral fuel tanks. Weight saving has always been important in aircraft design and manufacture, and with supersonic aircraft it becomes doubly important. This then is a strong argument in favour of integration.

(c) *Strength.* The reduction in the number of joints, with their associated slip, leads to greater general rigidity of the structure with integral construction, and this is generally claimed to be an advantage. The reduction in the number of bolt and rivet holes should improve the fatigue life. On the other hand, I am told that the larger the original forging, the harder it is to ensure that the grain flow in the finished part is satisfactory. Perhaps someone in the audience can quote the results of strength tests of comparable specimens.

(d) *Shape and Surface Finish.* With high speed aircraft as we know them to-day, and for at least the next generation of such aircraft, smoothness and lack of waviness in the external surface is of great importance in keeping the drag low. Further, "repeatability" of this smoothness over a production run of aircraft is essential, and variations in profiles which are acceptable with aircraft of lower performance cannot be tolerated at transonic and supersonic speeds. Possibly when we go faster still it will be more important to have a surface which radiates heat than one which is smooth, but we are some way from that yet. A good surface finish is also important in aircraft of lower performance, and is a good selling point in civil aircraft. Undoubtedly it is easier to get this with the thicker skins and fewer rivets, bolts and joints associated with integral construction.

(e) *Speed in production.* Does integral construction make for speed in production? Many claim that it does, owing to the reduction in the number of parts which have to be drawn, manufactured, inspected and assembled, in other words, due to the simplification. It has also been suggested that by progressive development of machine tools, we should be able to achieve still greater simplification or automatisation, even to the extent eventually of feeding drawings or numerical quantities and rough machined parts into wholly automatic machines. However, that stage is some way off, and whilst some of the argument still applies, the possibility of errors at a late stage in a long machining cycle cannot be completely discounted, as I mentioned before, and these can cause very serious delays. Another point which must be considered is the time taken to make the dies, forgings, etc., in the first place. I have a feeling that overall there is probably a saving in time with integral construction, but I should like to hear what you think about it.

(f) *Flexibility.* I have used this word to cover such matters as the ease of adaption of methods to suit changing demands, such as substantial modifications to the original designs, or a change of design. In a field in which the state of knowledge is advancing as rapidly as it does in aircraft design, modifications will always be with us, whether due to changes in operational requirements, faults found subsequent to manufacture or advances in technical knowledge, and it is essential that any method of construction shall allow modifications to be made quickly and smoothly. Further, because we cannot afford to build

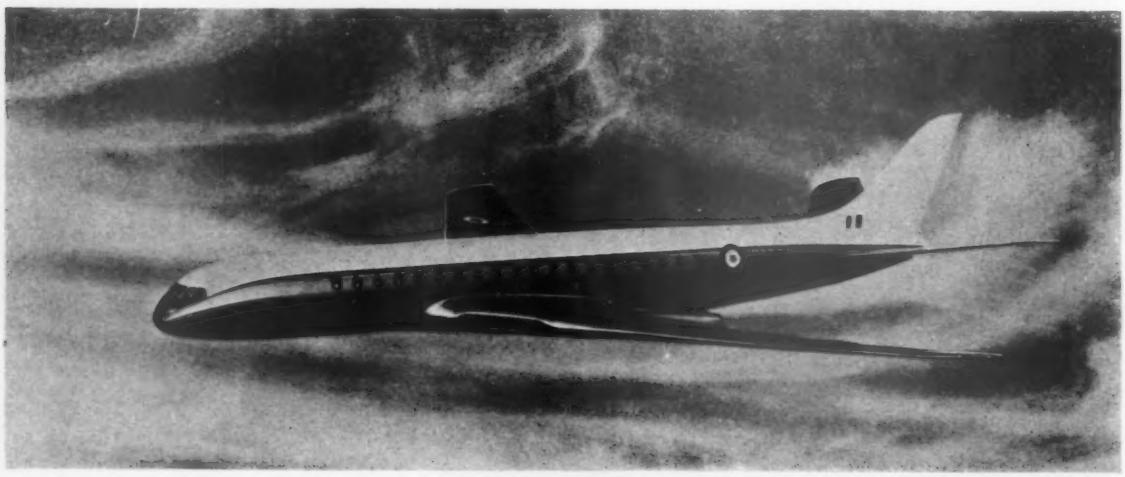


Fig. 26. Vickers 1000 model.

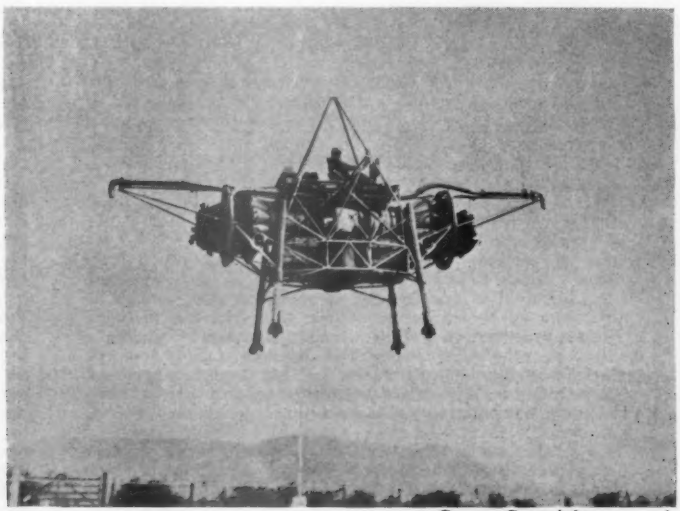
Fig. 27. Bristol 173 helicopter.

the very expensive and complicated aircraft of the future in very large quantities, any costly plant and tools involved should be capable of handling the components for a series of designs. This may severely limit the degree to which integration can be applied. Under this heading comes also the question of the possibility of rapid expansion of output, such as might be required in war or at the threat of war. Might not this be made more difficult if we adopted greater integration in construction, bearing in mind the extent to which aircraft manufacturers have relied on sub-contracting in the past? To what extent should we have to duplicate expensive plant and facilities?

(g) *Concentration of resources.* Allied with flexibility is the question of dispersal. Would not a greater reliance on the products of large presses, rolling mills, and costly and complicated machine tools, mean a dangerous concentration of our resources in one or two localities? It has been said that we took this kind of risk in the last War and got away with it; but does that mean that we should do it again? Further, would there not be a risk of serious hold-ups in production if some of the key plant or tools broke down or was put out of action? These are problems which give considerable food for thought.

(h) *Other factors.* There are other factors which depend on the methods of construction adopted. One is how the maintenance and repair of aircraft in service are affected. Will integral construction make aircraft easier or harder to maintain? Another

Fig. 28. Convair XFY-1 vertical take-off aircraft.



Crown Copyright reserved.

Fig. 29. Rolls-Royce 'Flying Bedstead'.

important factor is how easily is an aircraft adaptable for retrospective modification. There are doubtless many others which I have not mentioned but which will come to your minds. I think, however, that I have said enough to indicate that the issue is not altogether straightforward and simple.

Getting Together

I hope that in the discussion some of you will provide answers to the questions I have posed. However awkward these questions are, you have the somewhat doubtful consolation that they are no more awkward than are many other questions which face aircraft designers and production engineers, and which they can only answer by getting together.

It is on this note that I should like to end. Sir Richard Southwell once said that aircraft engineering was ordinary engineering made more difficult, and I think that statement is as true of the production side as it is of the design side. Aircraft production engineers have to keep pace with a speed of development which would be quite incredible in other fields.

During the last ten years, for example, the performance of aircraft has more than doubled in several respects. This alone makes it essential for the designer and production engineer to work in the closest possible collaboration and to try to appreciate each others' problems. I am convinced that every advance in the art increases the importance of such collaboration right from the earliest stage, so that the finished product must not only fly well but manufacture well. Gone are the days when the long-haired designer dreamed up superb new vehicles which could fly, oh, so fast and far and high, if only someone could manufacture them.

Gone also are the days when the production engineer

> "Left him at large to his own dark designs,
> That with reiterated crimes he might
> Heap on himself damnation".

What Milton said in the 17th century applies equally forcibly to the evolution of efficient aircraft to-day. Designer and production engineer, each has his part to play; success demands that each part shall be played well.

Acknowledgments

I should like to acknowledge the useful advice and assistance which I have received from my friends in industry and colleagues in the Ministry of Supply, and to thank those firms who have kindly provided photographs, diagrams or slides. I have also to thank my Department for permission to give this Paper, whilst confirming that I alone am responsible for any opinions expressed in it.

DISCUSSION - SESSION I

Chairman : Air Marshal SIR HUGH WALMSLEY, K.C.B., C.B.E., M.C., D.F.C., Managing Director, Air Service Training, Ltd.

Professor E. J. Richards, M.A., B.Sc., *(Professor of Aeronautical Engineering, University of Southampton)* said he had been asked to open the discussion for one reason only, namely, to welcome to the University of Southampton all those attending the Conference.

He congratulated Mr. Woodward-Nutt on his Paper. Far from the Ministry side being "the sidelines", it was by far the most important and difficult side of all. He would regard it as far easier to produce an aeroplane than to decide, in a sensible way, to the greatest advantage of the country, which aeroplane was the right one to build. The Conference was fortunate in having a Paper from someone who had to make those decisions.

Looking through the Paper, he had been fascinated by something on which the Author touched only lightly. Fig. 1 was a comparison of the expenditure on military aircraft in the U.S.A. and the U.K. over the last few years, and the Author said: "My only comment is that the number of major aircraft manufacturers is approximately the same in each country". In the United Kingdom the expenditure was of the order of one-twentieth of that in the U.S.A., and, if the number of manufacturers was the same, presumably it meant that even allowing for the difference in monetary values, the British firms were only about one-fifth of the size of the American firms.

It would be interesting to know what the Author regarded as the solution of this problem. One answer might be that this country was on the wrong track in going in for these bigger and better aeroplanes. The alternative was for the firms either to join together or agree to produce fewer types of aeroplane in the future.

There was a point regarding integral construction which Professor Richards wanted to make, in the light of that comment. How was it possible to make fewer types with an industry having its present set-up? It would be wrong to tell the big firms to buy up the little ones. One saw everywhere that very big firms were often less efficient than they might be. The alternative was for a number of firms to agree to make parts of aeroplanes. If development continued on present lines and aeroplanes became more and more complicated in ten years' time the present complication would appear to be child's play; the smaller firms, therefore, might very well and with advantage agree to specialise on parts of aeroplanes. He would like to see—

and he would like to know whether the Author regarded this as feasible—a few firms deciding to specialise on making wing structures. He would like to see the expensive capital equipment necessary being sent to the smaller firms, not to the bigger ones, and used for specific purposes such as wing shaping. One firm would concentrate on the integral construction of wings, and would have all the equipment which would allow it to do so very much better than others. Incidentally, that would keep the design side together, because the firm would both design and make wings and so be a strong constructional unit. There should be a great advance on the structural side in that way so far as wings were concerned.

He would like to see fuselages made in one place in the same way. In view of all the problems involved in regard to fatigue, reduxing and so on, it would be reasonable for firms to put out fuselages. Reference was made in the Paper to the danger of bombing when concentration of production took place, but that was happening now with undercarriage makers, on the electrical side and with radio equipment makers. His suggestion would only mean an extension of that, and it would be an efficient means of getting over the problem of British firms being so small for the job.

Professor Richards asked the Author to comment on that, because it would become a fundamental matter in the next ten years for the aircraft industry.

The only other comment he wished to make concerned the organisation of the Conference. He was very pleased to see that this year it was concerned with a single topic, that of integral construction. It occurred to him that as the subject of a future Conference it would be very useful to consider the education of those engaged in production, a topic very close to the hearts of himself and his colleagues. Production consisted of men, machines and materials, and he had yet to be convinced that enough attention was being given to the men, who were probably the most important of the elements involved. It would be valuable to discuss how to get the men to do what was required. The men who would do the work in twenty years' time were at present in the schools and would later be in the universities. What was to be done about that? It was not a question for the Author, but for the Conference as a whole. Men were more important even than materials and machines.

Mr. K. L. C. Legg, B.Sc.(Eng.), D.C.Ae., A.M.I.Mech.E., A.F.R.Ae.S., *(Structural Development Engineer, Short Bros. & Harland Ltd.)* challenged the Author's forecast of materials for supersonic aircraft. He did not think that the titanium alloys could be lightly dismissed; his firm had machined some into panels and tested them and the results had been extremely promising.

On the question of the cost of equipment, one large aircraft of advanced type might cost £1,000,000, while a large machine tool might cost £150,000. One fewer aircraft, therefore, would cover the cost of six or seven machine tools, which in turn, due to their production economy, were likely to be able to save the cost of the large aircraft. Production would become more efficient and the machines obtained in that way, as it were for nothing, would provide the extra capacity needed to help wartime production.

Reference had been made to the scrapping of large machined parts. He believed that it would be necessary to face a complete reorganisation of, or at least a different outlook on, maching in general. There was no doubt that a revolution was pending in machining techniques, and it showed considerable promise.

An important matter which required emphasis was the use of integral construction for fuel tanks. He had gone out of his way to discuss this point with air line operators in this country, and there was no doubt that they viewed integral construction very favourably from that point of view. That was not surprising in view of the long delays and loss of revenue which air line operators had experienced due to leaks on fabricated tanks. It was only fair to say, however, that recent improvements in methods of fabrication and inspection had considerably reduced those troubles.

Mr. W. S. Hollis, B.Sc.(Eng.), A.F.R.Ae.S. *(Assistant Director, Aircraft Production Development Branch, Ministry of Supply)* said that if there were to be fewer aircraft there would be less real need for complicated jigging; and jigs were very expensive. Moreover, jigs were not universal, but machine tools could be designed to fit a range of known circumstances. If a general lead was given by designers, in the use of integral components, production in its turn would make the machine tools.

He felt that Mr. Legg, in giving an estimate of £150,000 as the cost of a large machine tool, was over-estimating. A wing profiler should cost about half that amount. The price bore a reasonable relation to the cost of the aircraft and jigs. Integral construction had been shown to save approximately 30% of the cost of a wing.

Where circumstances suited, there was a tendency for some manufacturers to use redux or similar bonding methods. There had been over the last two or three years, however, a general swing towards integral construction, and he felt that there was now an insistence for the method, the machine tools and the materials.

It had been said that automatic machine tools were further away than might be imagined, but in this country prototype automatic electronic machine tools produced as a private venture were operating and a good deal of work had been carried out in the U.S.A. He believed that; in the next two or three years, automatic electronic machine tools would be available which would give a degree of control far greater than the machine tool could respond to. From that point of view there should be no hesitation in going ahead with integral construction and envisaging automatic machine tools dealing competently with the tasks.

Mr. J. Hall *(Development Engineer, Blackburn and General Aircraft Ltd.)*, dealing with the materials for use with integral construction, said that, in common with perhaps the majority of those attending the Conference, he believed that integral construction would of necessity become one of the major methods of producing aircraft of the nature dealt with that morning, and, although the Author had said that light alloys might cease to be used in this field, they would of necessity remain for some time to come. The use of titanium was still in its infancy. DTD 683 had been in use for many years, and in his view that material had been one of the biggest banes to the production engineer of any that had been devised.

The Author had referred to the potential scrap in machining very large pieces of integral plate. That was not necessarily due to the machinist or to the machine itself; very frequently, when large parts were machined, flaws were found or cracks developed. Sometimes, when 35-ton material was used, the designer had to reduce the ultimate stress to something like 30 tons because of the range of variation in its elongation. There was also trouble due to distortion of the material when large chunks of it had to be machined away. The production engineer had therefore to handle the material with great care, and that led to one of the worst bottlenecks.

The Ministry of Supply could help in this connection, because almost invariably the specifications for material were based on what the supplier required, but all too little was said for the information of the user. A very useful adjunct to any specification of that nature would be an appendix giving the machinability, formability and so on. At present different firms dealt with the same material in different ways.

Mr. B. Stephenson *(Chief Designer (Aircraft) Vickers-Armstrongs Ltd.)* did not believe that there was any real controversy about the use of integral construction; he thought that it was as inevitable as the change from wood to metal and from fabric covering to metal covering, so far as the aircraft of the future were concerned. From the point of view of design there could be no question that the efficiency of the structure was improved. Having designed the structure, however, he thought that the greatest danger was going to be the inability to make last-minute modifications, which were so familiar in aircraft work. Last-minute

modifications might introduce stress raisers, and the inability to deal with them might be a stumbling-block. The time taken from the production of drawings to the production of the finished article must inevitably be longer, because it was a question of producing a finished product.

Mr. G. H. Taylor *(New Development and Process Engineer (Aircraft), English Electric Co. Ltd.)* endorsed what Mr. Hall had said about the problem of distortion with integral construction. They were all aware, he said, of the deficiencies of DTD 683 so far as distortion was concerned, and he would like to know how they should be corrected and controlled. A great deal of emphasis should be put on this point.

Mr. A. Vines A.M.I.Prod.E., *(Production Manager, Fairey Aviation Co. Ltd.)* said that the question of integral construction would come up in other lectures, in connection with the difficulty of making big forgings, etc. There were certain distinct categories to be considered, i.e., sheet for making wing skins 1 or 2 in. thick, 8ft. wide and 30 ft. long and slabs 4 to 6 in. thick and 2 to 3 ft. wide for making ribs and spars, etc. Also he would like to ask, how big was a big forging? There had been talk of 40,000 ton to 70,000 ton presses which the Americans had developed, but forging sizes were difficult to obtain. The trouble in the U.K. was that they had not invested enough money in production equipment, for material manufacture or machines. Every Ministerial Department and every aircraft firm would like to experiment, but the wherewithal to plunge into a new form of construction was not always forthcoming. That was the great disadvantage from which this country suffered at the moment.

They read reports on integral construction in America and he thought the majority of the industry would use it in one form or another if they had the materials and the machines but the Americans were already in production, and a lag of five years or more would have to be put right by some sort of combined operation within the industry. The designer took the view that he would like to make a component from slab or a big forging if he could get it, but he wanted to know what the properties of the material would be and the delivery, which at the present time was impossible to estimate as proper equipment was not available. When the designer was told this, he had to find some alternative method. Unless some action was taken we should continue in this state for an indefinite period. The complete solution of the problem of distortion in machining big slabs was to stretch them, but there was no definite move on foot to produce the equipment, so that they could be machined with confidence.

He would appeal to all who were concerned—and it was not confined to one firm or one branch of the Ministry—to look at this matter in a much bigger way and see whether they could not, as a nation, equip themselves to make use of integral construction which had now been accepted as an advantage which they could not afford to ignore. The investment was small compared with the cost of prototypes, but unless the material was right no rapid expansion was possible. Indeed, if rapid expansion had to take place they would be even worse off because they would not have done the fundamental work which was necessary in order to expand properly. There might be people present who could put their heads together and solve the problem. It had been under consideration for a long time and he felt there was enough evidence available for action without delay.

Mr. F. F. E. Mountifield, A.M.I.Prod.E., *(Works Manager, Mervyn Instruments Ltd.)* supported the plea of Professor Richards for the education of the manpower of the industry. It would seem, he said, that there were going to be revolutionary changes in the machine tools of the future, and in the methods of using them, such as electronic instruments, with computers to feed information into the instruments for the control of the machines, and a new type of operator would be necessary to operate such machines. The operator would perhaps require to be a man of the calibre of a jig borer, a man able to calculate and supply information to the machine before its use. It was necessary to begin to train people to use these future methods. Until that was done one could foresee that there would be considerable amounts of very expensive scrap, due to the old-fashioned type of operator trying to use a more modern type of machine tool without the fundamental knowledge necessary in order to do so.

Mr. T. Gilbertson, M.I.Prod.E., *(Director and General Manager, Folland Aircraft Ltd.)* said that the Author had referred to the integral construction of the American Super-Constellation and had remarked that wings made in that way probably cost a good deal more than those made by conventional methods. Someone must decide whether the extra cost of integral construction was worth paying from a military standpoint.

An interesting point in the Paper which might have escaped notice was the comparison of kilowatts and weight of radio and electrical equipment. The weight of the equipment in a modern bomber was 60 times greater than that of the Hampden of the 1930's, but the power consumption was only about 16½ times greater; in kilowatts per pound weight, a ratio of 1 to 25 for the Hampden and 1 to 90 for the modern machine. In spite of this improved power/weight ratio there was still need for research in that direction to reduce weight.

They had been hearing for a long time now about the merits of integral construction, and he had been worried about it not so much from his point of view as a production engineer, but from a national standpoint. It deserved careful consideration on the part of the Ministry of Supply and those who would be responsible for directing the labour resources of the country in time of war. In the last War, the country had not reached the stage of integral construction and only survived by the ability to produce fighters such as the Spitfire in garages and sheds up and down the land. That had been possible by the use of women and other unskilled labour, leaving the technical resources of the country to be used in other directions.

The desire which was shown in some quarters today to go flat out for integral production, with the use of immobile presses and other large pieces of machinery which required special skills to manipulate them, would tend to put this country, especially on the military side, in a dangerous position. He did not think that it was wise on the part of the Ministry to decide in favour of a military aircraft using integrally produced components. Something had been said about the difficulty of introducing modifications in such a case, but he thought that was a small point compared with the possibility of producing the aircraft at all. Militarily, consideration must be given to how such an aircraft was going to be produced when the manpower of the country had been called up. It would be a question of "scratching machines out of the earth with our fingernails". People with no skill whatever would have to be taught how to produce the parts.

Integrally produced ribs might have to be produced on jig borers, and there was a tendency to drive parts from drilling machines to jig borers, which were costly and not easily transported and for which it was difficult to find operators. It was to the scarcity of skills that consideration must be given when deciding on the type of construction to be adopted. If apart from this consideration he had to express a preference, he would say that a rib was better integral, and so was a skin, but that was not the issue; the issue was whether the resources would be available at the right time for military aircraft.

Mr. Woodward-Nutt, replying to the discussion, said that he could only deal briefly with some of the points raised. **Professor Richards** had made some very interesting and constructive suggestions. The question whether there should be fewer firms was a difficult one. It would be easy for the principal customer to decide that we could only afford to have "x" firms, but the value of new blood must be borne in mind. Any policy on where to make things must be flexible enough to allow bright ideas to come forward.

Whether it would be feasible to have wings and fuselages made by specialist firms, he did not know. Most major firms were willing to subcontract their undercarriages, but

he doubted whether they would be willing to subcontract their wings, or even their fuselages.

He thought the suggestion for a discussion on the education of production engineers was attractive.

Mr. Legg had accused him of lightly dismissing titanium, but that was the last thing he had intended to do. The comments in his Paper had been intended to refer to aircraft of the present day and of the immediately following generation. He did not think that there was likely to be any saving in weight in these aircraft by using the titanium alloys at present known as a substitute for steel or light alloy in the main structure, but he might be wrong; he was not an expert.

He could not completely follow **Mr. Legg's** arithmetic, nor that of **Mr. Hollis.** Neither had mentioned the *number* of aircraft over which the costs would be amortised. **Mr. Hollis** might be right about simplifying jigging, but although there would be fewer aircraft each was going to be larger and more complex.

Mr. Hall had suggested that in material specifications more heed should be taken of user requirements, and such points as machinability covered. That was a useful suggestion, and he would see that the people responsible for specifications heard of it.

Mr. Stephenson, whilst welcoming the advent of integral construction, had stressed the difficulties raised by last-minute modifications. It was probably known that for military aircraft the M.O.S. were going to try a new system and, instead of ordering one or two prototypes only, proposed in future to order a "development batch" of ten or twenty aircraft, over which there would be gradual change from the first "hand-made" aeroplane to the final production version. They hoped that one result would be that there would be fewer modifications when the type got into service. **Mr. Woodward-Nutt** did not suggest, however, that it would ever be possible to do without "mods" altogether.

He was not qualified to answer **Mr. Taylor's** question about the alleged deficiencies of DTD.683. He understood, however, that some aircraft manufacturers at least had learned how to get the best out of this material, and had found it very satisfactory.

He could but agree with **Mr. Vines** that if we had more money we could experiment more with new constructional methods. The difficulty was, however, that all the money for aircraft came from the same place in the end, namely, their own pockets.

He fully agreed with **Mr. Mountifield** on the importance of educating those who had to operate expensive and complex machines.

Mr. Gilbertson had mentioned the Super-Constellation wing panel. He agreed that the extra cost had to be weighed against the other advantageous factors. He noted that **Mr. Gilbertson** agreed with his point about the danger of too great a concentration of resources. In the last War, all our aircraft were dependent on propellers made in two places in the country only, and if those had been knocked out we should have been in a position of grave difficulty. He could assure **Mr. Gilbertson** that the decision to order a certain type of military aircraft was unlikely to be made because the type was or was not capable of being made by integral constructional methods. There was always a very careful weighing of many and various factors, including the ability to produce it in war conditions.

The Conference then adjourned for luncheon.

CONFERENCE LUNCHEON

THE CHAIRMAN, Mr. F. T. West, M.B.E., M.I.Prod.E., A.I.Struct.E., M.R.San.I., Principal, Southampton Technical College, and Chairman, of the Southern Section of the Institution welcomed all those attending the Third Conference on "Problems of Aircraft Production". To the Mayor of Southampton, he said, they extended a special welcome, because his interest in education and in the training of young engineers was well known to the Southern Section and they were well aware of his many visits, with his gracious lady, to the Engineering Department of the Southampton Technical College. The Chairman asked the Mayor to convey to his Education Committee the very best thanks of the Institution for what they were doing for production engineering.

The Chairman also offered a special welcome to Sir Edward Boyle, Parliamentary Secretary to the Ministry of Supply, and expressed the pleasure of the Conference at the presence of the Vice-Chancellor of the University of Southampton, Mr. D. G. James, whom he thanked for permission to hold the Conference in the University, at the same time asking him to convey their thanks to his staff. The Chairman also thanked the Secretary of the Institution, Mr. W. F. S. Woodford, and the Hon. Secretary of the Southern Section, Mr. J. W. Taylor, for all that they had done to make the Conference a success.

The Mayor, he said, had been interested all his life, not only in this country but overseas, in production—the production of food, which was more important than the building of aircraft.

The MAYOR OF SOUTHAMPTON (Alderman R. E. Edmunds) said he had always been interested in things mechanical, and as a youngster might have become an engineer, but he would have had to wait six months to be apprenticed. He decided that that was too long, and so went into another sphere, in which, however, many mechanical devices were used. He welcomed all those attending the Conference to Southampton.

He wondered what the future held. He could recall the early days of the Wright brothers, and only the other day he had flown to London on the first helicopter trip in the Southampton to London service. One day it might be possible to strap an individual helicopter on one's back and fly !

He appreciated all that the engineering profession was doing for Southampton by establishing factories

Sir Edward Boyle, Parliamentary Secretary to the Ministry of Supply (right) has a chat with the Mayor of Southampton (Alderman R. E. Edmunds) and Mr. F. T. West, M.B.E. (left), Chairman of the Southern Section of the Institution. One of the Conference speakers, Mr. A. W. Menzies, can be seen between Sir Edward and the Mayor.

in the town. He hoped they would find Southampton not only a suitable place for their Conferences, but an appropriate site on which to establish further activities.

Sir EDWARD BOYLE, Bt., M.P., *Parliamentary Secretary, Ministry of Supply,* said he would like to thank the Institution of Production Engineers very sincerely for doing him the honour of inviting him to address them to-day, and to congratulate them on their initiative in arranging these regular conferences on aircraft production. He also congratulated the Mayor on having such an agreeable city as Southampton in which these conferences could meet, and he congratulated the Vice-Chancellor not only on being Vice-Chancellor of this very fine University, but also on the fact that the University had recently obtained its Charter.

He was relieved that the Chairman did not read the notes about him (Sir Edward) which appeared in the programme, because he was there described as Parliamentary Secretary to the Ministry of Supply and also as a director of a private firm. In case anyone felt that was grossly irregular, he would like to say that one of his very first actions on arriving at the Ministry of Supply was to resign his directorship!

"Those of you who attend these conferences" Sir Edward continued, "must find them, I am sure, of the greatest value and must very much appreciate the opportunity they afford for pooling ideas and experiences. I believe I am right in saying that on an earlier occasion one of these conferences gave rise to a little controversy in the press, but I do not think that it was any the worse for that; I do not think there is any harm done if that happens from time to time.

Delays in Delivery

"At the present time a great deal of public attention is being given to delays in aircraft deliveries, and particularly delays in the delivery of fighter aircraft. As a junior member of the Government, I make no complaint at all of these criticisms. After all, the prime responsibility of any British Government is to secure this island against attack. No reasonable person can deny that during the last year there have been setbacks and disappointments. What is obviously desirable, however, is that this criticism should be so far as possible informed criticism, based on a real understanding of the problems which face the British aircraft industry to-day.

A Fundamental Point

"There is one fundamental point which I wish to emphasise at the outset: our present difficulties are not so much difficulties of production as essentially difficulties of development. I have seen in the press some references to Lord Beaverbrook's work at the Ministry of Aircraft Production during the War. I yield to no one in my admiration for the vigour which Lord Beaverbrook showed when he held that office in wartime, but it is worth remembering that by the time he became Minister of Aircraft Production the problem was one not of development, but of producing certain types of aircraft, the design of which was already fixed. The problems which face us to-day are different.

"It is worth remembering that aircraft development before the War was also a slow business. The development of the Spitfire, for example, goes back to the Schneider Trophy races of 1927 to 1931. I can just remember those races; they are amongst the earliest things that I do remember. They led to the reappearance of the monoplane. The specification for the Spitfire was given, I think, in 1935, and it took five years to develop it, from 1935 to 1940. It is fair to say that if the War had come a year earlier, we should not have been in at all a happy position so far as fighter aircraft were concerned. The position was slightly different with regard to tanks, and in tanks we should have had a reasonable superiority a year earlier; but for fighter aircraft the extra year made a great deal of difference, and it was only in 1940 that we were ready to go into large-scale production on the Spitfire. The fact, therefore, that the Hunter aircraft, ordered just after the beginning of the Korean War, are only now beginning to go into squadron service is not so very disgraceful by past standards, especially when we remember, first of all, the greater complexity of modern aircraft; secondly, the very considerable current aerodynamic problems; and, last but not least, the difficulties which we faced during the period of disarmament after 1945.

"I do not want to say anything further now about the consequences of disarmament or the reasons for them, because this is not a political occasion and I shall keep off that completely; but I do want to say a few words about the complexity of modern aircraft and about certain current aerodynamic difficulties.

"I believe I am right in saying that the design and performance of a modern aircraft have advanced more rapidly than the design and performance of any

other contemporary product. Here are a few figures which illustrate that point. In 1940, a fighter weighed 2½ tons; to-day a modern fighter will probably weigh five or six times that amount. A current British day fighter requires some 12,000 to 15,000 production drawings, and a V-bomber some 20,000. The number of jigs and tools required for a V-bomber is approximately 135,000. The Hampden bomber, built in the late 1930's, carried less than 150 lb. of radio and electrical equipment, whereas the corresponding figure for a modern bomber is something like 9,000 lb. A wartime fighter carried 2 miles of cable and its radio equipment included 20 valves; a present-day fighter carries 6 miles of cable and 140 radio valves. The length of cable in a bomber has risen from 8 miles to 19½ miles, and its radio valves have increased from 50 during the War to 1,000 to-day.

"Those figures illustrate the great complexity of modern aircraft, and for security reasons I have tended to under-state rather than over-state my case.

"All this complexity adds to the administrative problems. The Ministry of Supply Directorates deal in total with no less than 600,000 separate items of equipment. Here I should very much like to pay tribute to the work done by the Directorates in the Ministry of Supply. Already, after six months in that Ministry, I have had experience of how helpfully and efficiently they work.

"This morning you have heard from Mr. Woodward-Nutt something about trends in future aircraft design, and he will have described to you how complex and difficult are the current problems of aircraft construction. I do not propose myself to go very far into the technical field; I have not the time or the knowledge required to do so. I should, however, like to refer very briefly to one or two of the ways in which modern aircraft are dependent on developments in industry. This is an aspect of the subject which is of special interest to me, since I represent a constituency in the industrial Midlands.

Future Requirements

"We are giving a great deal of thought at the present time to the future requirements of modern aircraft construction. For example, there may well be a need for new and larger forging and extrusion presses. There will be a need for new rolling mills to make longer and thicker slabs of aluminium alloy, and there will be a need for the development and manufacture in this country of skin milling machines which can shape these large slabs. Moreover, as aircraft reach high supersonic speeds we are faced with an increasing problem due to the heat generated by air friction, what is sometimes not quite accurately called the "heat barrier." That is a very difficult problem and will affect our choice of materials. No doubt when we start to use titanium and to make increased use of steel for very high speed aircraft, a completely new set of manufacturing problems will arise.

"Mention of high supersonic speeds leads me to say just a few words about current aerodynamic problems. Aerodynamic difficulties become acute as we approach the speed of sound, owing to the action

Mr. F. C. Cooke (second from left), a past President of the Southern Section, discusses the first Session with members of the Section Committee. From left: Mr. J. B. Turner; Mr. Cooke; Mr. T. Gilbertson; Mr. D. L. Wiggins; and Mr. R. J. P. Masters.

of shock waves. For aircraft to fly at a speed of $M=0.97$ is an enormous step forward from a speed of $M=0.90$. These difficulties which we face in flying at very high speeds, approaching the speed of sound, can be revealed fully only through flight trials. Wind-tunnel tests are very valuable, but they do not tell us everything. For example, it was only as a result of flight trials that we came to appreciate how serious was the problem of the dive-brakes of very high speed fighters. It is clear that the sooner we can get aircraft to do their initial flight trials, the better it will be from the point of view of speeding up development.

"It is these aerodynamic difficulties which can be revealed only in flight trials which make it so difficult to avoid the need for modifications. Here again there is an increasing problem, because these modifications are far more difficult and laborious to execute than they used to be. I am always told when going round factories that exactly the same thing is true in other fields as well; it is not only in the field of aircraft that modifications after test are much more laborious and difficult to execute than they were some years ago.

"I should like to say a word about the future and what we are doing to ensure that we shall not be so worried by delays in deliveries of super-priority aircraft in future years. There is no doubt that in the past the proper development of new types has been handicapped by shortage of prototype aircraft. The few prototypes available have had too much to do and have often been torn between conflicting tasks and priorities. Furthermore, early production aircraft have in practice had to be used virtually as development aircraft. It is the shortage of prototypes in the past which led the former Minister of Supply, Duncan Sandys, to announce last March that in future the Ministry of Supply would order up to 20 development aircraft where this seemed desirable.

The "Development Batch"

"This idea of what we sometimes call the "development batch," of ordering up to 20 development aircraft, does not mean that firms will just build 20 prototypes as quickly as they can; the idea is

rather that each of these development aircraft should reach a more advanced standard than the one before, so that we really reach full production standard by the time that the twentieth has been completed. In other words, what we want is for development to merge smoothly into production.

"This policy will require very close co-operation between the Ministry of Supply and the various aircraft firms concerned. It will also call for the closest co-operation inside each firm between the design teams and the production teams. I know that there are risks involved in this policy, as in all policies. From the financial point of view the development batch will mean that aircraft firms will have to lock up a large amount of capital in these development aircraft. I am sure, however, that the policy of the development batch is fundamentally sound and should help to speed up development very much in the future.

"One final point—military aircraft have long ceased to be simply flying machines. Military aircraft to-day have become complex weapon systems, and the various forms of equipment inside each aircraft are every bit essential to the defence of this country as the airframe itself. The construction of a modern aircraft requires not only a high degree of technical skill and experience on the part of individual firms, but also constant co-operation on the part of all the companies concerned.

"I would end by saying how happy I am to think that it is just these difficult and important problems which you will be considering at this Conference to-day and tomorrow. I hope that your Conference will be a very great success, and I wish all of you a prosperous New Year and the best of luck."

SESSION II (i)
AIRCRAFT PRODUCTION CONFERENCE

"PROBLEMS OF FORGING"

by G. W. RICHARDS.

Mr. Richards

Mr. Richards is a director of High Duty Alloys, Limited, a member of the Governing Council of the National Association of Drop Forgers and Stampers, and Chairman of the Light Alloy Section of that Association.

DURING the past ten years, there has been a marked change in the type of forging required by the aircraft industry. Until about 1946, the main requirements were for the engine builders in the form of pistons, crank cases, cylinder heads, cylinder barrels, reduction gear cases and many similar components. These parts were manufactured in aluminium alloys specially developed for such applications, and possessing good strength at temperature characteristics up to 250 - 300°C.

With the introduction of the Whittle engine, these alloys were found to be ideally suited to the manufacture of impellors, although very often such parts were of considerably greater mass than previously

required. Many of the ancillaries were also made as forgings in the same alloys.

Now, all the above components were subject to considerable machining before use and, accordingly, many were supplied to the engine builder in the soft or annealed condition. Heat treatment was carried out after rough machining, when the mass had been reduced as far as was practicable.

Certain forged components, however, did not lend themselves to this method of processing and, therefore, special heat treatment procedures were evolved to permit the development of good mechanical strength and at the same time maintain the internal stress levels at a minimum. Initially, such treatments were only possible if accompanied by a drop in strength of 25 - 33⅓%, but alloy development subsequently made it possible to provide minimum internal stress levels with no more than a 10% loss in strength, as compared with the fully heat treated material.

The forging requirement, therefore, in the period approximately 1945-1948, was for engine components in what have become known as the "medium strength alloys", all of which were generously machined before use. Thus the forged surface or forged skin was entirely removed during this operation.

Around 1948, there arose from the airframe manufacturer a demand for forged components of a very different category. Intricate shapes combined, in many cases, with thin sections were called for in the alloys possessing the highest mechanical strength levels then available.

The problems associated with the manufacture of such parts were not fully appreciated immediately, and indeed even today many problems remain to be solved.

Very generally one may liken the relationship of the medium strength aluminium alloys and the high strength alloys with the relationship of mild steel to high alloy steels. The high strength aluminium alloys are obviously more complex than the medium strength alloys and casting, extrusion, rolling, forging, machining and heat treatment present problems which were not encountered with the easier materials.

Co-operation Overcomes Problems

I should like to say here that these problems have been largely overcome by the very active co-operation of the aircraft industry with the material manufacturer and, in particular, I would like to express my appreciation of the manner in which the aircraft manufacturers, metallurgists and technical staff have co-operated with the forging industry. That is a very genuine statement. We still have a number of troubles, as you know, but many problems have been overcome by that very active co-operation.

Some measure of the degree of this co-operation is shown by the universal use of the high strength aluminium alloys in airframe construction today.

The airframe manufacturer's requirement, therefore, was for forgings which differed in most respects to the forgings required in the past by the engine builder. More complex design, thinner sections, close tolerance — all in high strength alloys — combined with a desire to machine the component only where it was absolutely necessary, were the main factors involved.

The production of a forged surface of suitable quality — free from folds and surface imperfections, etc. — was perhaps the major problem in the initial stages. It was not easy to detect superficial faults when the component was in the soft condition, and when revealed after heat treatment these faults were usually sufficient to reject the part. Such faults are, of course, formed or occur during the forging operation, usually as a result of either too much metal or too little metal at a specific point in the die, and the tough high strength alloys, with their greater resistance to deformation, tended to give much more trouble in this respect than the softer materials.

Chromic Acid Anodising

Chromic acid anodising of the heat treated forging was introduced as a means of inspection, and proved to be of considerable value in this connection. Components were given the normal anodising treatment and allowed to stand for some twenty-four hours before examination. Seepage of the chromic acid usually indicates the presence of a fold or crack, but it has been shown that this method is not infallible, and skill and experience are necessary in the preparation of the component during the anodising process and particularly at the washing stage. Polishing of the surface of forgings followed by anodising has been widely employed, and is by far the most searching form of inspection so far devised.

These, and other methods designed to improve the quality of product, are under active development both by the forgers and the aircraft manufacturers.

Complex designs, particularly where thin sections are involved, are extremely difficult to forge, and yet tremendous progress has been made during the past five years. Close to form compressor blade forgings for aircraft engines are outstanding, certainly one of the most spectacular, examples of this development. Airframe forging development has been less spectacular, perhaps, due to the smaller quantity requirement, but nevertheless the improvement in techniques in this field has been unsurpassed.

Production of Thin Sections

Thin sections are always difficult to produce, and for the high strength aluminium alloy forgings at least 20 tons per square inch pressure is necessary. Existing equipment limits the size of component it is possible to produce to approximately 600 square inches plan area, or say, a forging 48" long × 12" wide. This is, of course, a generalisation but will serve to illustrate one of the problems involved in the production of thin section forgings. With increased thickness, lower specific pressures are possible, so that one may say that if the ruling thickness is 1½" then a forging with twice the plan area mentioned above can be produced.

During recent years also there has been an unprecedented demand for forged slabs or blocks in high strength aluminium alloys. Such blocks are machined by the aircraft manufacturer to provide components for prototype aircraft. The production

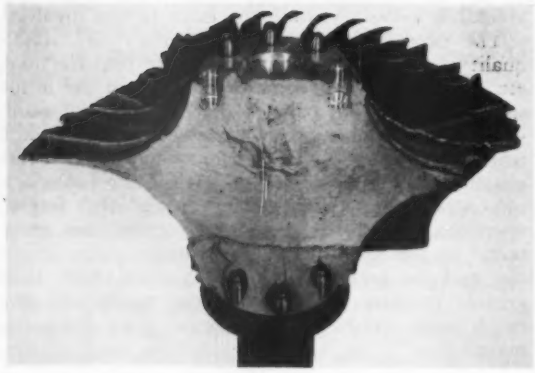


Fig. 1

of such slabs often involves the casting of billets of 1 - 2 tons weight of a suitable quality for forging. It is perhaps appropriate to point out here that five years ago such billets were not available.

The casting of these billets for forging has received close attention and study, and special forging procedures have been evolved to ensure the thorough working of the material essential for the development of full mechanical properties in the longitudinal, transverse and short transverse directions.

It is essential that the chemical composition is controlled to very close limits, for small variations can produce quite marked differences in properties. It is unfortunate and confusing that so many different compositions, all within the appropriate D.T.D. specification limits, should exist, for quite often it is only possible to obtain certain properties—for instance, full mechanical strength—at the expense of other desirable properties—for example, low level of internal stress.

This situation is brought about largely as a result of the use of a composition which although quite suitable for say, extrusions, is not so suitable for, say, forgings, because of the different manufacturing processes involved.

It is general practice to quench extrusions and sheet after solution treatment into cool or cold water. This has the effect of developing the optimum tensile properties, and the high level of internal stress induced by such treatment is reduced to a low level by subsequent processing by stretching, etc. It is obvious that this procedure can be applied to a product of uniform section, but cannot be applied to a forging of complex shape. Forgings quenched in cool or cold water will exhibit high internal stress levels, giving rise to severe distortion during subsequent machining, and sometimes complete failure by cracking may occur. Local correction of distortion can in turn sometimes produce disastrous results.

The solution to these problems is to ensure that internal stress levels are maintained at the minimum at all times.

Quenching from solution heat treatment should be in water at not less than 85°C. for small and medium sized components of irregular shape, and larger parts should be quenched at 90° to 95°C. By such

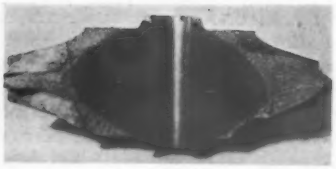


Fig. 2

methods, internal stress levels will be minimised and, provided the appropriate composition is employed, full specification mechanical properties can be maintained on tests cut from the component.

Importance of Quench Temperature

Great care must be taken to ensure that the precise conditions of heat treatment are maintained, not only in so far as solution heat treatment temperature is concerned. The importance of adequate temperature control of the furnace used for solution heat treatment is well known, but a point which is not always appreciated concerns the temperature of the quench. This, too, must be adequately controlled to give the precise temperature required uniformly throughout the bath, and the loads so arranged that a rise in temperature of up to 10°C. is achieved following the quenching operation. The quench bath must be maintained in a clean condition and the quench water constantly changed. If a salt bath is used for solution heat treatment, the quench water can become contaminated with the residue of salt adhering to the load, and quite small concentrations can completely change the quenching rate and give results comparable with those obtained by quenching into cold water. If a salt bath is used, therefore, it is necessary to change the quench water more frequently.

It will be obvious that it is undesirable to machine components of complicated form from material stock which requires to be cold water quenched in order to develop specification properties. It is sometimes possible to machine from fully heat treated stock which has been stress relieved by, say, stretching, but such methods are only applicable to relatively small components. Stock of greater section than

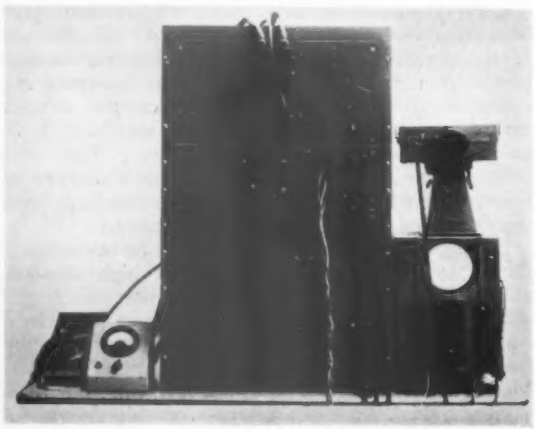


Fig. 3

about 3″ in the material requiring cold water quenching suffers from "mass effect" and full mechanical properties may not be obtained throughout the section.

The practice of ordering forged slabs as a stock item, of suitable size to make any of a number of components, is not desirable, although apparently sometimes unavoidable. Each part should preferably be considered separately, and a slab of appropriate size obtained to make the component. By such means, it is possible for the forging supplier to provide the most suitable product for the job in hand.

As soon as is reasonably possible, it is recommended that dies are provided for the manufacture of such parts, thus permitting improved material utilisation, reduced weight and the provision of a suitable grain flow within the component, in addition to the advantages to be gained by the utilisation of smaller initial forging stock.

Some further information, which may be of interest, on the effect of quenching conditions is shown in the illustrations to this Paper.

I have deliberately included two illustrations of internal stress failures obtained on forgings manufactured over ten years ago. Both examples are in medium strength alloy and these will, I hope, serve to remind you that some of our present day problems are not peculiar to the high strength aluminium alloys. Fig. 1 is of an impellor — early Whittle type, and Fig. 2 is of an impellor of smaller size — Sabre type.

For certain alloys, the boiling water quenching procedure as a means of controlling internal stresses at a low level has been standard practice for some

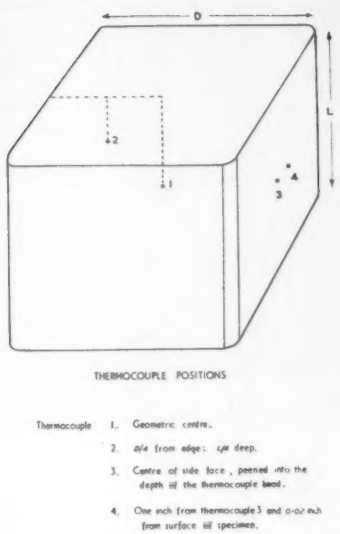

D
L
1
2
3
4
THERMOCOUPLE POSITIONS
Thermocouple 1. Geometric centre.
2. d/4 from edge: t/4 deep.
3. Centre of side face, peened into the depth of the thermocouple bead.
4. One inch from thermocouple 3 and 0·01 inch from surface of specimen.

Fig. 4

years. This procedure was set up as a result of extensive investigation, but until recently no measurements have been made of the temperature conditions which are developed during quenching of large specimens into boiling water. These measurements have been made possible by the introduction of a new high speed multipoint temperature recorder by Nash & Thompson (Fig. 3). This consists of a D.C. amplifier to which the thermo-electric voltages are applied. The amplified voltages are displayed on a

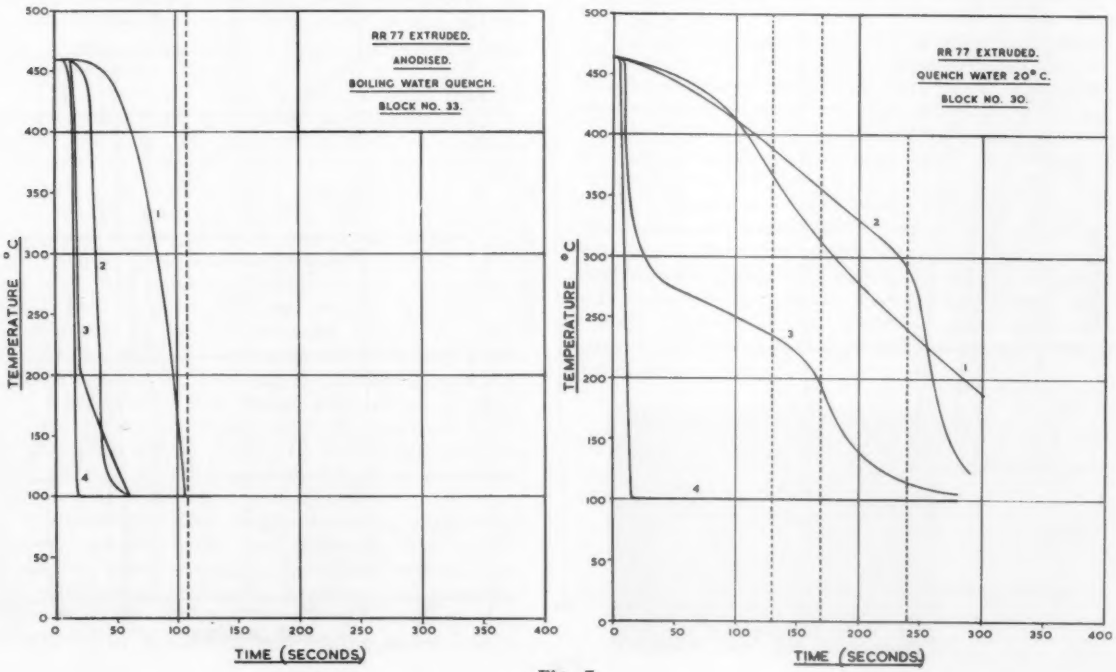
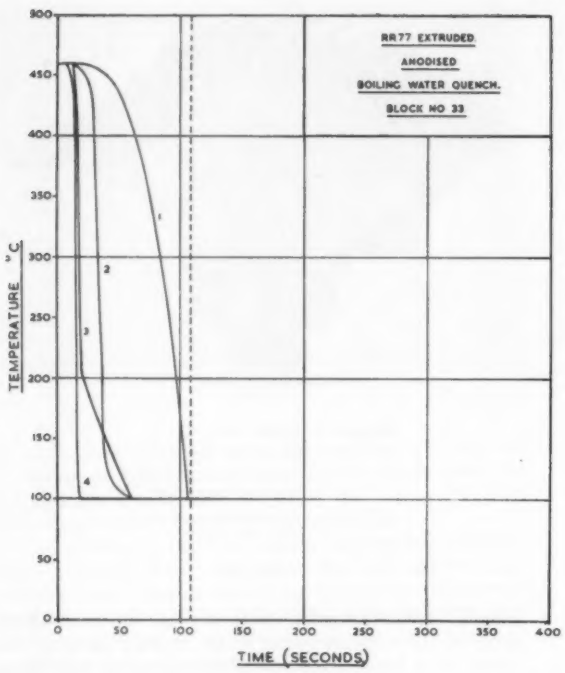


Fig. 5


RR77 EXTRUDED
ANODISED
BOILING WATER QUENCH.
BLOCK NO 33
TEMPERATURE °C.
TIME (SECONDS)

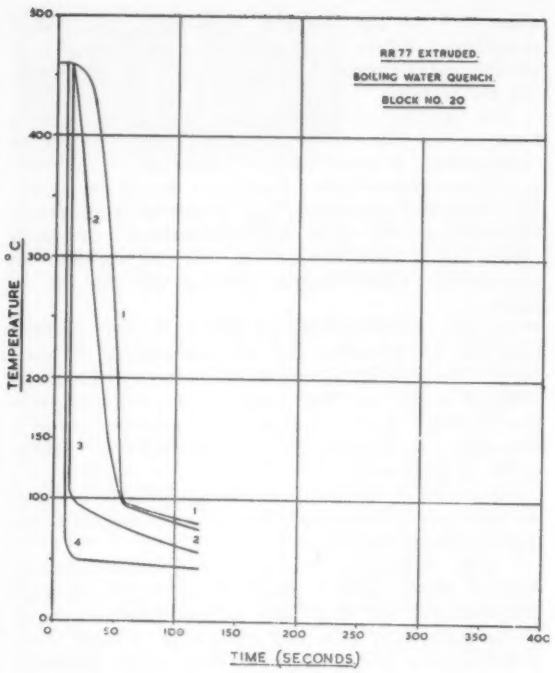
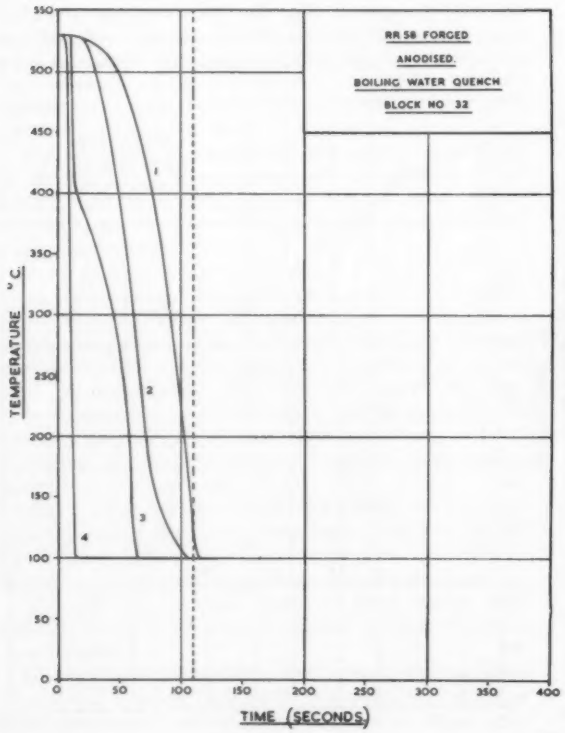

RR 77 EXTRUDED.
BOILING WATER QUENCH.
BLOCK NO. 20
TEMPERATURE °C.
TIME (SECONDS)

Fig. 6


RR 58 FORGED
ANODISED.
BOILING WATER QUENCH
BLOCK NO 32
TEMPERATURE °C.
TIME (SECONDS)

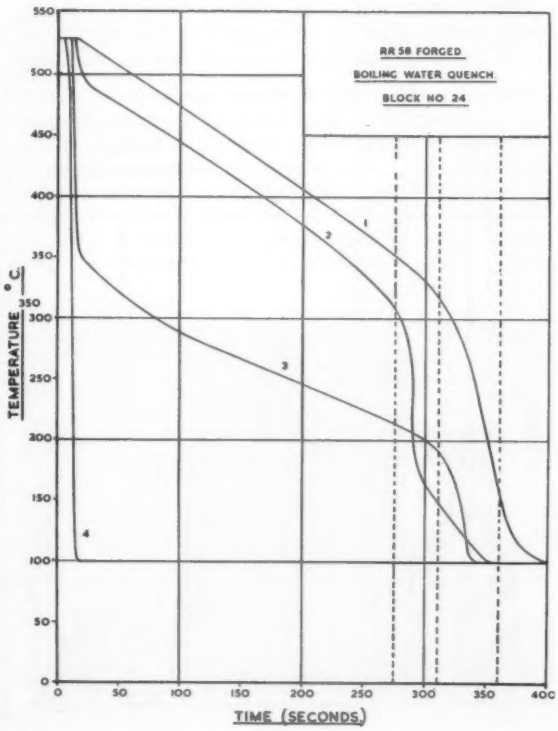

RR 58 FORGED
BOILING WATER QUENCH
BLOCK NO 24
TEMPERATURE °C.
TIME (SECONDS)

Fig. 7

cathode ray oscillograph, the deflection being proportioned to the thermo-couple voltage and hence to the temperature. Up to 20 thermocouples can be used with this recorder, each being selected by a rotary scanner running at 10 r.p.m.

The specimens used for the experiments are illustrated in Fig. 4. Four thermocouples were used to increase the speed of recording by five times. The thermocouples measured the temperatures at the centre of the block (thermocouple 1); at a point a quarter distance in from the side and a quarter depth, (thermocouple 2); at the surface, (thermocouple 3); and just off the surface in the quenching medium. (thermocouple 4). The results of the measurements on each of these specimens were plotted as quenching diagrams, the diagrams showing the cooling curves for the four thermocouples.

Fig. 5 shows the cooling diagrams for specimens in RR.77 (DTD.683) quenched into boiling water. The specimen represented by the curve on the left was anodised before heat treatment; that on the right was in the as-manufactured condition. The curve on the right shows some interesting features. First, the thermocouple measuring the quench temperature fell very rapidly to 100°C. while that measuring the temperature at the surface of the specimen fell rapidly to about 300°C. and then more slowly. At about this temperature, the curves for thermocouples 1, 2 and 3 showed a marked 'knee'. This 'knee' occurred during the 'second boil', a feature during the quench when the water suddenly boils vigorously from an apparently quiescent condition. The peak of the second boil is shown by the central vertical dotted line and the beginning and end by the dotted lines on each side.

In sharp contrast, the curve on the left shows the influence of anodic treatment of the specimen. All thermocouples gave extremely steep cooling curves. The characteristics of the boiling water quench have been profoundly affected.

It is interesting now to look at the diagram corresponding with quenching into water at 20°C. shown in Fig. 6. This diagram is shown in combination with the left hand diagram from the preceding diagram. It will be seen that quenching of an anodised specimen into boiling water is practically equivalent to quenching an untreated specimen into cold water. That is an extremely interesting result, and may not be generally appreciated. In general terms some appreciation was possible prior to the introduction of this new recorder, but by its means we have been able to make actual records and explain quite a number of, if not all, the problems associated with heat-treating these rather large pieces of metal.

This effect is also true of another alloy, Hiduminium RR.58 (DTD.717, DTD.731) as can be seen in Fig. 7. Hiduminium RR.58 is, of course, classified as a medium strength alloy.

It is clear from these diagrams that the temperature of the quench water can influence the cooling conditions much more than would be expected from the temperature difference involved, and it can be shown that the internal stress level is reduced most effectively by quenching into boiling water. As an indication, a specimen quenched into cold water cracked (Figs. 8 and 9), and a spot measurement of internal stress gave a value of 10 tons per square inch. A similar spot check on an identical specimen quenched into boiling water gave a value of about 5 tons per square inch.

Fig. 8

The effect of anodising prior to heat treatment is extremely drastic. The quenching diagrams for boiling water quenching correspond to a water quench temperature of about 20°C. and the internal stress level is found to be well over 9 tons per square inch.

I hope this Paper has been of interest. I have tried to point out some of the forging problems and also some of the problems involved in processing the forging.

First-class forgings in the high strength aluminium alloys to a wide variety of designs have been in use, and have given excellent service results, for many years. Present trends in design demand shapes and sections which are thinner and more complicated. Existing equipment for the manufacture of such parts is limited, and will have to be expanded to meet this trend. Largely as a result of this limitation of plant, the demand for large slabs from which the component can be machined, has greatly increased. Some of the problems associated with high levels of internal stress, particularly in such parts, have been discussed, with details of some of the possible causes and some suggestions which have proved in practice to be beneficial.

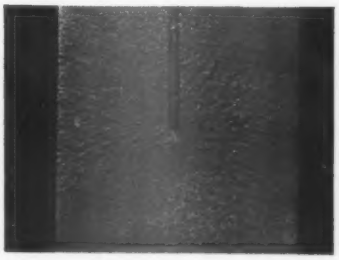


Fig. 9

MACHINING AND FORMING PROBLEMS OF INTEGRAL CONSTRUCTION

by E. D. KEEN, B.Sc.(Eng.), F.R.Ae.S. and A. W. MENZIES.

After obtaining an Honours degree externally at London University in 1928, *Mr. Keen became assistant to Major H. N. Wylie, then a consultant to Sir W. G. Armstrong Whitworth Aircraft, Limited. Shortly afterwards he was transferred to the firm's Test Laboratory staff in Coventry, and in* 1931 *joined the Stress Section of the Design Department. Mr. Keen was appointed Research Engineer and Deputy Chief Technician in* 1939, *and took up his present post of Assistant Chief Designer in* 1948.

Last year he was awarded the Simms Gold Medal by the Royal Aeronautical Society for his Paper, 'Integral Construction—Its Application to Aircraft Design and Its Effect on Production Methods'.

Mr. Keen

Mr. Menzies

After completing his apprenticeship in a shipyard, Mr Menzies joined Armstrong Whitworth Aircraft Limited in 1923. *After a period as Foreman, he was appointed Superintendent, Machines Fabrications and Details.*

Whilst Senior Superintendent, Mr. Menzies was a member of the Anglo-American Productivity Team on Pressed Metal, which visited the United States in 1949.

He is now Process Development Manager at Armstrong Whitworth Aircraft, Limited.

PROGRESS in airframe design has led to phenomenal increases in loading co-efficients, which means in effect providing structures to withstand much higher loads in a much smaller space. This is most dramatically illustrated in the thickness of wing skins required on modern high-speed fighters, and design studies on faster machines with even thinner wings show that this tendency is increasing. (1). The term 'integral construction' has hitherto been rather narrowly applied to the process of fabricating the stiffeners necessary to stabilise a relatively thin skin to take compression loads in one piece with the skin itself. In its broadest sense, however, it can be applied to the whole process of reducing the number of component parts in a modern aircraft structure, due to the sheer inability to make joints in very highly loaded parts without severe complication and weight penalties. Perhaps a more general term to describe

the present phase in aircraft design might be 'integrated structures', and it might well be the penultimate phase culminating in carving the entire airframe out of the solid.

A great deal has been written about the advantages of integral construction such as a reduction of component parts, reduction in assembly time, increased structural efficiency, etc. It may well be, however, that in the not-too-distant future the types of structure now being described as experimental will become the only solution to the difficult structural problems which lie ahead. Much has been said about the costly machinery required for the manufacture of integrally stiffened skins. Modern aircraft need many more machines than their more lightly loaded predecessors. and already the integrated form of construction exemplified by the H.T.S. spar root end fitting described later is using a great variety and quantity of very expensive machines.

This Paper, whilst concentrating on some of the experimental work which has been done and is still in progress on integrally stiffened skins, also covers the wider field of integrated structures by including information on the machining of large and complicated fittings which, in an earlier age, would have themselves been built-up structures. In this sense integral construction is with us to a limited extent today. How rapidly the infiltration will progress, only time will tell.

Integrally Stiffened Skins

Early Development of the Machined Wing.

In August, 1946, Patent No. 22904/46 was filed as a result of some investigations into the production of laminar flow wings by the production engineering department of Sir W. G. Armstrong Whitworth Aircraft, Ltd.

What the works thought about the efforts of the Design Office to make laminar flow aeroplanes is contained in the opening sentences of the patent which run: "Considerable difficulty has been experienced in manufacturing the built-up structure of a smooth-surfaced aerofoil, particularly of an aircraft wing, owing to the extremely fine limits of accuracy which are required to avoid disturbing the laminar flow characteristics," and later on: "The main objects of the invention are to provide an improved wing and method whereby the same can be constructed accurately and far more simply and quickly than has hitherto been possible, the method particularly lending itself to repetition production methods". The last part was a particularly vicious dig at the Design Department. Evidently the Production Departments considered that the designs they were then struggling with were not suitable for production methods.

The proposals took the form of rectangular extrusions which were milled into channel sections.

The wing section was made up by bolting a number of such channel sections together, thus forming a kind of "plank" construction, For the first trials the largest extrusion which could be obtained was 4 in. x 3 in. x 17 ft. with rounded edges, so that the

Fig. 1. Machined wing flange "plank".

largest finished machined width that could be made was 10 in., as shown in Fig. 1. At that time the only machine which could handle this type of work was a spar miller. To form the wing contour on the outer wing surface, the cam bars were removed and a form block was placed on the cam brackets. A milling cutter ground to a radius was used. The minimum practical skin thickness when machined in this way was approximately 0.15 in.

As a demonstration of the practicability of the technique, this trial proved what it set out to do. Various refinements to the design were then made in order to apply it to a practical example. It was realised from the first that the construction was heavy and suitable only for high structural loadings. Secondly, intermediate stiffeners would be required to stabilise the skin to withstand a reasonably high compression stress. Thirdly, the shape of the stiffeners was far from ideal from a structural point of view. At this time, however, Z- or T-section stringers were thought to be impracticable, so a design study was made of the application of the best that could be done to the centre section of an Apollo wing. The design worked out is shown in Fig. 2. Two intermediate stiffeners were added to the basic 10 in. wide "planks" enabling the skin thickness to be reduced to 0.10 in.

A detailed study of the relative costs of the machined construction and the existing construction was made, showing that while the cost of material is roughly doubled, saving on details and assembly time using machined panels results in a reduction on overall costs of nearly 30 per cent. In assessing the actual cost level it should be pointed out that the wing section used was a laminar flow type and the original construction, admittedly expensive, with its closely spaced corrugated stiffeners, was adopted in an effort to secure a transition point as near as possible to the theoretical value of 0.5 of the chord from the leading edge of the wing.

Because of the specialised nature of the original construction the weight of the machined alternative compared favourably and the cost estimates bore out the original contentions of the specifications. Tests were made on half-scale compression panels.

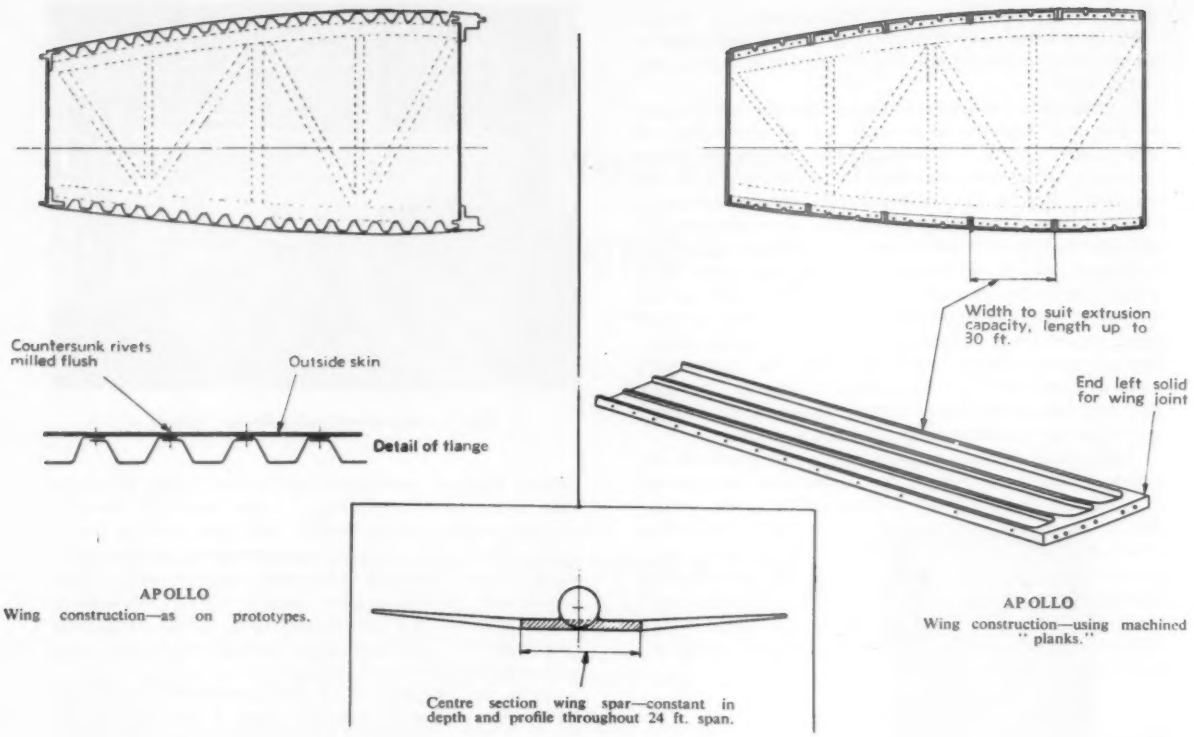

Countersunk rivets milled flush
Outside skin
Detail of flange
APOLLO
Wing construction—as on prototypes.
Centre section wing spar—constant in depth and profile throughout 24 ft. span.
Width to suit extrusion capacity, length up to 30 ft.
End left solid for wing joint
APOLLO
Wing construction—using machined "planks."

Fig. 2. Apollo centre section comparison.

These showed that the obvious improvements of increased depth of stringer, better forms of stringer in the shape of T- or Z-section, and a reduction in the ratio of stringer to skin area were necessary before any approach to ideal conditions could be obtained. Such a construction could not, of course, be universally applied since the dimensions were considered to be practical minima and therefore quite unsuitable for the lightly loaded outer wings of a civil aeroplane. For a rib pitch of 15 in. the flange loading was 3·75 tons/in. width, a figure applicable only to the centre section of the aircraft wing considered. This is really not within the range of flange loadings considered to be necessary to justify the use of this form of construction from a structural efficiency point of view.

The Intermediate Period

Partly because of the lukewarm reception given by the structural experts to this new form of construction, difficult to justify for aircraft designs then current, and partly because of preoccupation with post-war rearmament, in the United Kingdom interest seemed to flag. Gradually, however, news came of developments in America, and of increasing activities in this field. By now a great deal has been published about the American achievements and it is not intended to repeat the details here. It was not until design studies for aircraft with greatly superior performance were being prepared that it was fully realised that the days of wrapping comparatively thin sheets over an internal rib structure, thereby springing it to the desired contour, were numbered. Indeed, it was already being realised that sheets of the thickness required had to be pre-formed by rolling, but before long the required contours would have to be obtained by machining, stretching, or forging. Even in the limiting case of unstiffened thick sheet, rolls of vastly greater capacity would be needed and machining would probably be necessary to obtain the required surface finish. Above all, such sheets must be tapered to conform to the graduations of load carried.

The whole problem seemed to take on a new meaning. This new concept was no longer an oddity —it looked more like the shape of things to come, whether we liked it or not. The next question was: were we prepared to meet it? Without a doubt no machinery existed even to make a start. Other requirements, such as producing and machining heavy forgings, required bigger and better machines, and a policy of obtaining larger equipment was vigorously pursued. General purpose machines such as the Hydrotel copy miller and large Hufford stretcher presses were obtained, and new rolling machines installed. In spite of these improved tools,

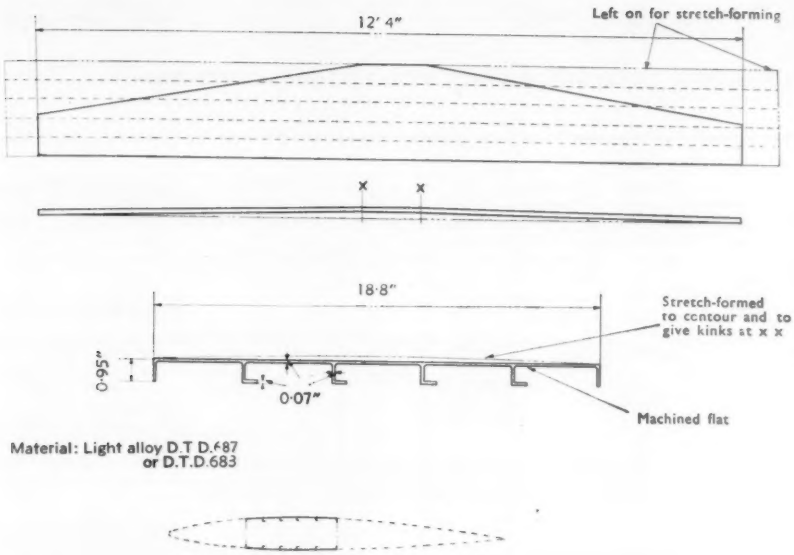


Fig. 3. Machined flange for Meteor tail plane.

doubt still existed as to whether they were of the right kind; were they large enough, could they produce the surface finish required, which method of manufacture would be quickest, cheapest and most satisfactory?

Recent Developments

A considerable amount of work is now going on in this country on exercises to learn the new technique. Many of these have no direct application to specific aircraft which show an immediate advantage, but nevertheless much valuable data is being accumulated and experience gained. Specific reference is made in this Paper to two projects, but it is known that others are at hand. The general feeling, however, is that progress is slow and is considerably hampered by lack of machine tools, particularly skin millers. It is also necessary to provide for bigger units of raw material together with the handling plant, such as stretch and roller levellers, to manipulate the larger billets.

Meteor Tailplanes

After many proposals had been made, a contract was placed with Sir W. G. Armstrong Whitworth Aircraft Ltd. to produce three Meteor tailplanes with the box spar flanges of integral construction. From a structural point of view the exercise was not very satisfying, as this particular tailplane is too thick and too lightly loaded. However, valuable lessons have been learnt on the practical side, particularly as the work has been done on existing machinery in spite of obvious limitations. Fig. 3 shows the construction adopted for the main box spar. Originally it was intended to produce the three specimens in identical ways, i.e. by machining to the desired shape from the solid without any further manipulation.

Soon after the job was begun it was realised that an opportunity existed for examining other potentially more economical ways of doing the job. Firstly, it would be easier if the stiffeners and skin could be machined flat and afterwards formed to the curved contour. Secondly, one of the most serious criticisms of the machining method is the great amount of metal to be removed and the excessive time required to remove it. Material extruded or forged to nearly the required shape is obviously preferable. It was found that extrusions of tube form complete with stiffeners could be obtained in the United Kingdom, but machinery for opening it out in even the moderate length required for this job was not available. There seemed little point in making provision for this if the stretch forming of the flat flange produced by machining was not successful. The revised programme therefore was in three stages:—

Stage I Machined from solid to required contours without any further forming process.

Stage II Machined flat from solid billet and stretch-form subsequently.

Stage III If Stage II proves successful, split a tubular extrusion, flatten out and stretch-form to contour.

In the event, development on this particular project did not progress beyond Stage II and the final programme followed is shown in Table I.

From this it will be seen that only the first flange was produced as described in Stage I. The other five were produced by Stage II methods.

TABLE 1

MANUFACTURE OF METEOR TAILPLANE FLANGES WITH INTEGRAL STIFFENERS

Tailplane Number	*Flange*	*Billet*			*Heat Treatment before Machining*	*Machine Process*	*First Stretch Form*	*Solution Treatment*			*Second Stretch Form*	*Artificial Ageing*
		Size	*Material*	*Condition*				*Method*	*Temp.*	*Quenchi'g*		
1	Bottom	13′-4″ x 21″ x 1½″	Forged DTD 683	Fully Heat Treated	None	Contoured on Cincinnati Hydrotel	None		None		None	None
	Top	14′-8″ x 21″ x 1½″	Forged DTD 683	Annealed	None	Butler Planer	Light pull (6.2 tons per sq.ins.)	Air Furnace	465°C	Vertically in warm water	27.6 tons pull (15.3 tons per sq.ins.)	Air 135/147°C for 20 hours
2	Top & Bottom	14′-8″ x 21″ x 1½″	Forged DTD 683	Fully Heat Treated	Annealed	Butler Planer	Light pull	Air Furnace	480°C	Air & Water	27 tons approx. pull	Air 135/147°C for 20 hours
3	Top & Bottom	14′ x 41″ x 1½″ (for two flanges)	Hot Rolled DTD 687	Solution Treated	Annealed	Top:- Butler Planer Bottom:- Butler Planer & Hydrotel	Light pull	Air Furnace	480°C	Water Spray & Water Immersion	27 tons approx. pull	Air 133/135°C for 20 hours

So far as Stage III was concerned, suitable extrusions could have been obtained but no flattening plant existed at the manufacturers and the firm were not willing to install it.

At the outset it was realised that a careful choice of billet would considerably reduce the amount of machinery required. This is illustrated in Fig. 4, which shows the economy of material possible by selecting the appropriate billet size and shape in conjunction with the alternative methods of production outlined above.

For the first flange, machined all over to contour, a kinked billet thick enough to contain the curved section in a chordwise direction was used. After trimming the edges of the billet the outside face was rough machined on the Hydrotel copy miller, using a hemi-spherical end mill moving spanwise. The billet was clamped round the periphery at intervals of about 2 ft. The copy was made of wood with a facing of light alloy sheet. The billet was then turned over and the inside was rough machined as shown in Fig. 5. The copy block in this case was a female cast in low melting point alloy from the wooden pattern used for the outside, with the addition of wooden strips to reproduce stringers. Smoothing cuts were next taken on the inside surface with the cutter moving chordwise. The stringers were then cut with a side mill traversed spanwise.

Finally the outside surface was finish machined as shown in Fig. 6. This was followed by removal of excess material around the periphery on a planing machine. The machined finish was not at all satisfactory due to the type of cutter used, dictated by the type of contour follower on this machine. This is illustrated in Fig. 7, which shows that the final surface is inevitably composed of a series of ridges, the height of which is determined by the feed for each successive cut. The smaller the feed, the better the finish but the longer the machining operation. The conclusions from this first flange were that this process of copy milling was quite useless on a time basis and, furthermore, the hand finishing required would be quite unacceptable in production. Considerable distortion occurs during the machining process, making consistency in thickness difficult to achieve. Measurements after removal from the

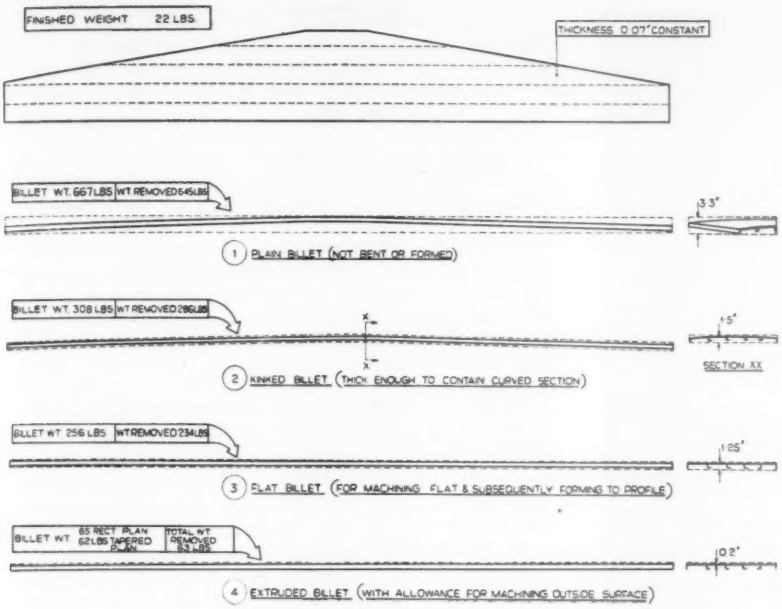

FINISHED WEIGHT 22 LBS.
THICKNESS 0.07" CONSTANT
BILLET WT. 667 LBS. WT REMOVED 645 LBS.
.33"
1 PLAIN BILLET (NOT BENT OR FORMED)
BILLET WT. 308 LBS. WT REMOVED 286 LBS.
.5"
SECTION XX
2 KINKED BILLET (THICK ENOUGH TO CONTAIN CURVED SECTION)
BILLET WT 256 LBS. WT REMOVED 234 LBS.
1.25"
3 FLAT BILLET (FOR MACHINING FLAT & SUBSEQUENTLY FORMING TO PROFILE)
BILLET WT 65 RECT. PLAN 62 LBS. TAPERED PLAN
TOTAL WT REMOVED 63 LBS.
.02"
4 EXTRUDED BILLET (WITH ALLOWANCE FOR MACHINING OUTSIDE SURFACE)

Fig. 4. Alternative forms of billet for tail plane flange.

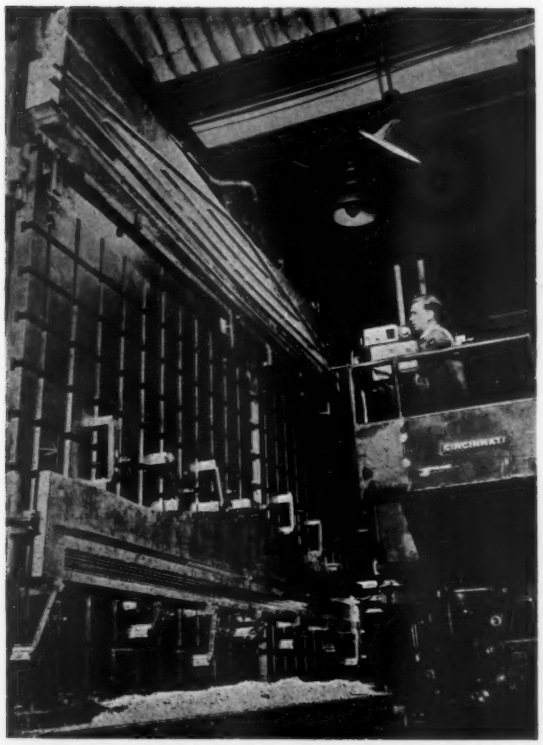


Fig. 5. Rough machining inside of first Meteor tail plane flange.

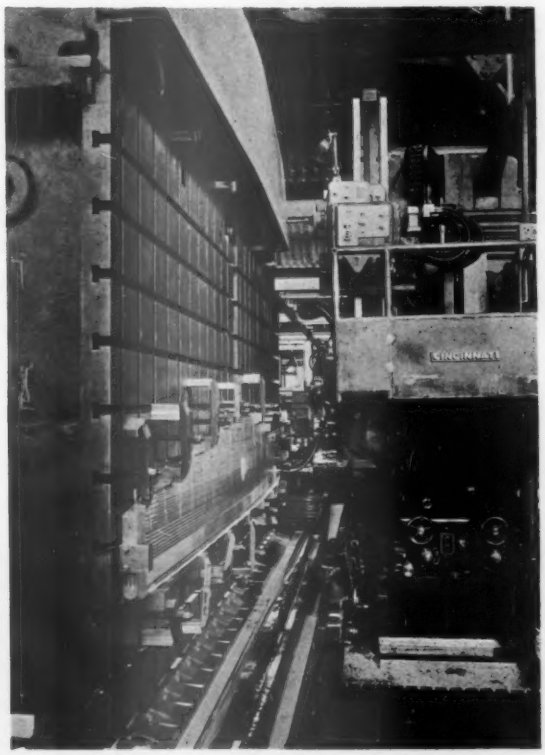


Fig. 6. Finish machining outside of first Meteor tail plane flange.

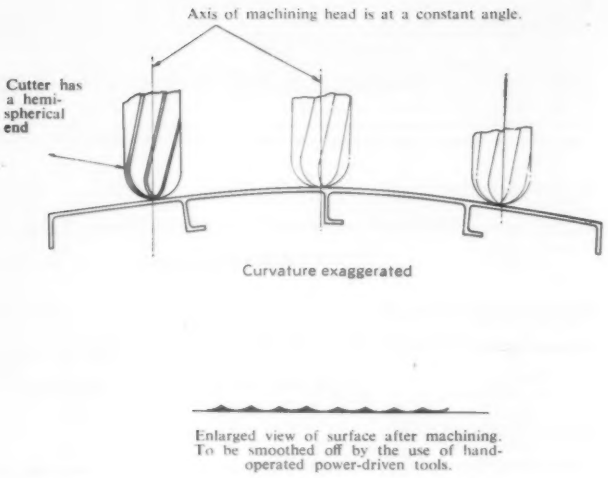

Axis of machining head is at a constant angle.
Cutter has a hemi-spherical end
Curvature exaggerated
Enlarged view of surface after machining. To be smoothed off by the use of hand-operated power-driven tools.

Fig. 7. Machining contour on Hydrotel.

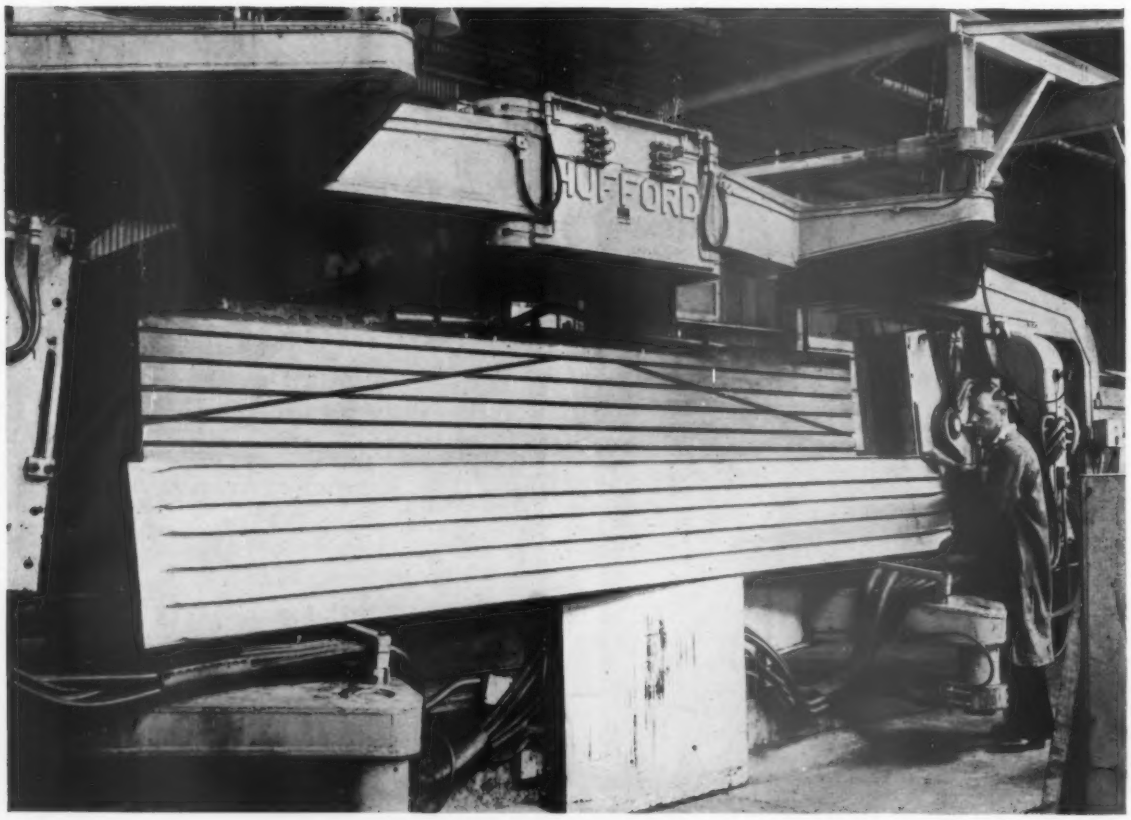


Fig. 8. Meteor flange No. 2 after light pull (annealed condition).

contouring machine showed considerable variation over the skin surface. As the flange is a relatively thin one, the general distortion was eliminated by pulling down on to the ribs. This, of course, would have not been possible with a thicker flange.

The second flange was therefore machined flat on a planer and stretch formed on a Hufford stretcher press. Because it was not possible to stretch a tapered section, the flange was made parallel initially and trimmed to shape as a final operation. To minimise distortion during machining, the outside and inside surfaces were rough planed followed by finishing the inside and finally the outside, all the machining being carried out with the material in the annealed condition. The flange was then stretch formed to contour (including the dihedral kinks) with a light pull on the Hufford press. The formed flange, together with the form block used, is shown in Fig. 8. Solution heat treatment was then carried out at H.D.A. (Redditch) and the final stretching process performed within five hours. Fig. 9 shows the distortion after solution treatment and Fig. 10 shows the finally stretched flange, from which the distortion has been removed by a pull of 27.6 tons corresponding to a mean stress in the flange of 15.3 tons/ins^2. The final heat treatment was then carried out without further distortion. This process was undoubtedly more practicable than that used for the first flange and it was decided to manufacture the rest of the flanges in this way. The time was reduced to 1/18 of that previously taken, and the accuracy was considerably better, the skin thickness being within the limits +.000 in. to —.004 in. of the nominal (.070 in.) thickness. The smoothness of the outside contour, however, tends to be marred by flats between stiffeners.

Whilst the general methods of production of the remaining four flanges were similar to that described above for the second flange, several variations were made. For the next two flanges, a successful method of minimising the distortion caused by solution treatment was devised by quenching in two stages. During the first stage the flange was cooled by cold air from twelve air lines playing on to the flange from both sides, movement of the jets being made thoroughly to circulate air which induced a rapid drop in temperature to 200-250°C. The second stage consisted of lowering the flange into a water tank to complete the quenching process.

The last two components were made from hot-rolled DTD. 687 plate material. This necessitated a revision of the two-stage quenching process in which the air jets in stage one were replaced by a water spray for about twelve seconds and then immersed in water. This process is illustrated in Figs. 11 and 12. A further variation in the machining process of the last flange was made by cutting the stringers and finishing the inside surface on the Hydrotel, as illustrated in Fig. 13, instead of on the planer. In this case a suction bed was used to hold the work down. (NOTE: The clamps seen in the figure were used as a safety device in the event of suction failure.)

One of the finished tailplanes is shown in Figs. 14 and 15. These clearly show the attractive finish obtained, particularly the absence of rivets.

Fig. 9. Distortion after solution treatment.

It is considered, however, that a more perfect finish could have been obtained by leaving an allowance on the skin and afterwards removing it on a properly designed contour milling machine.

Box Spar

The second practical experiment to be referred to is a research project initiated by Short Bros. and Harland Ltd., supported in part by a Ministry of Supply contract.

To investigate the considerable advantages indicated over riveted construction and the practical difficulties involved, it was decided to manufacture a spar box structure, employing integral construction, to compare with the existing spar box of the S.B.5 aircraft. To complete the exercise, a strength test under representative fully factored aircraft loads was conducted. The project, therefore, provided a direct comparison with an existing riveted skin-stringer spar box. A pictorial view of the spar box, together with its riveted forerunner, is shown in Fig. 16. The upper and lower surfaces were integrally machined and conventional spar webs and ribs were employed. The lack of assembly complication and reduction in parts are clearly apparent.

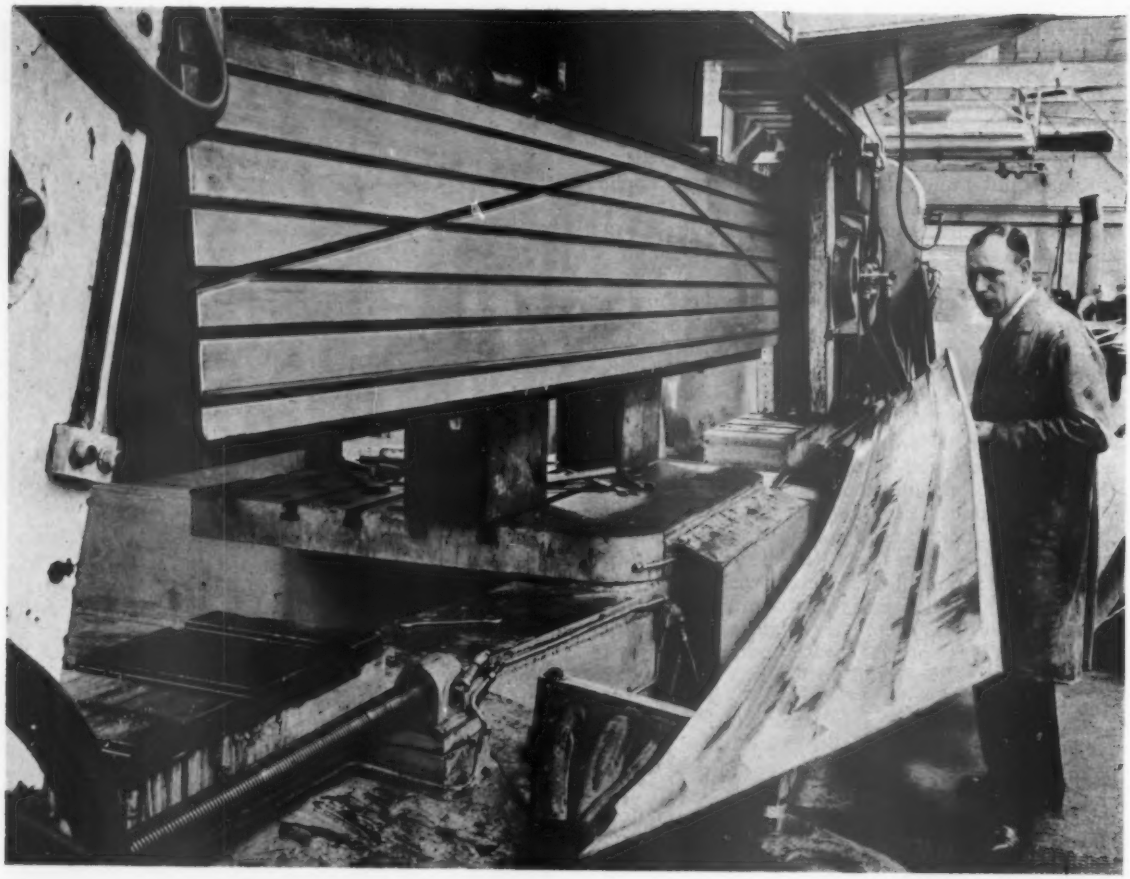
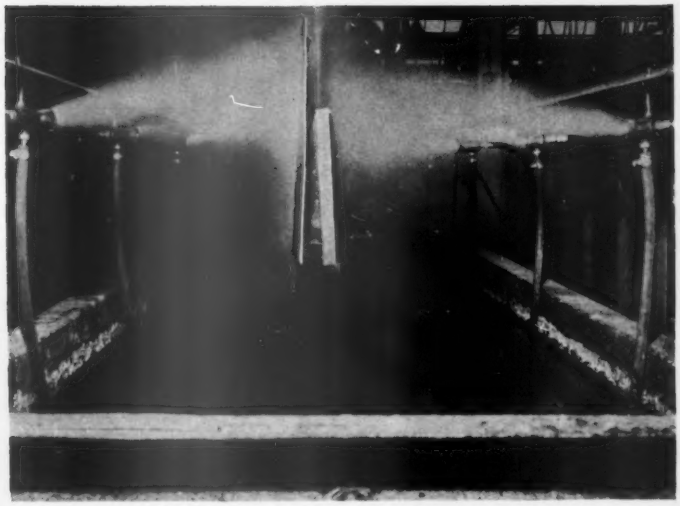


Fig. 10. Finally stretched flange.

Fig. 11. Water spray quenching for DTD. 687.

Fig. 12. Water spray quenching for DTD. 687.



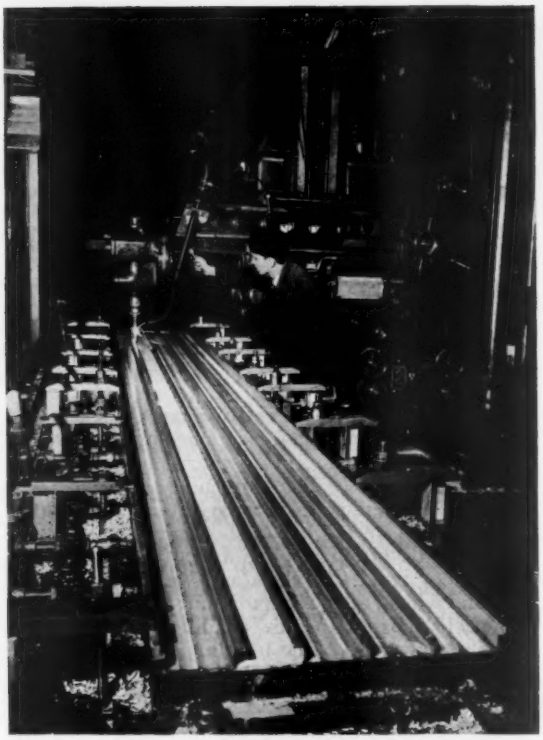


Fig. 13. Milling on the Hydrotel using the vertical head.

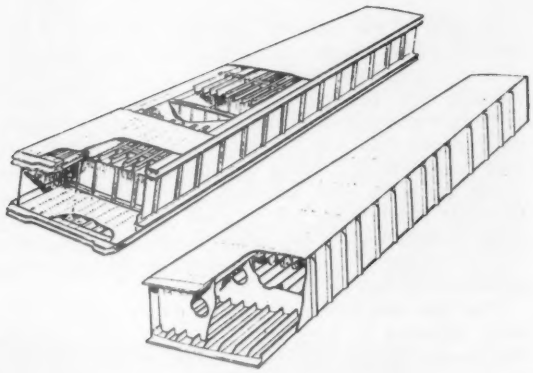


Fig. 16. An integral construction box spar project (Short Bros. and Harland).

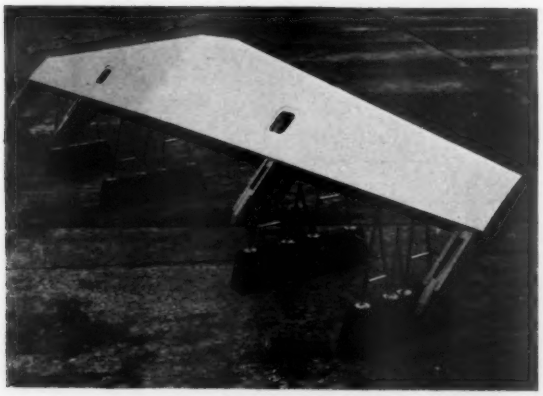


Fig. 14. Finished Meteor tail plane—outside.

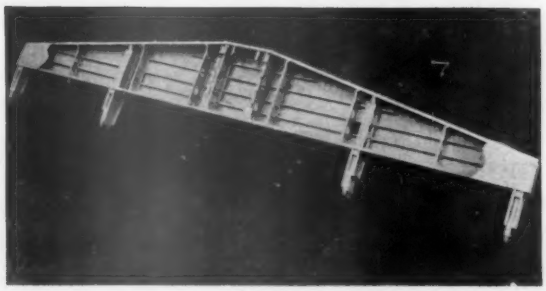
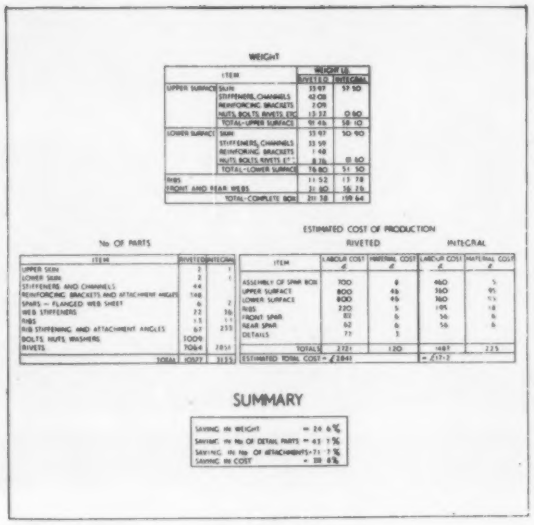


Fig. 15. Finished Meteor tail plane—inside.



WEIGHT

ITEM		WEIGHT lb. RIVETED	WEIGHT lb. INTEGRAL
UPPER SURFACE	SKIN	33·97	57·50
	STIFFENERS, CHANNELS	42·08	
	REINFORCING BRACKETS	7·09	
	NUTS, BOLTS, RIVETS, ETC.	13·32	0·60
	TOTAL—UPPER SURFACE	96·46	58·10
LOWER SURFACE	SKIN	33·97	50·90
	STIFFENERS, CHANNELS	33·09	
	REINFORCING BRACKETS	7·48	
	NUTS, BOLTS, RIVETS ETC.	8·76	0·60
	TOTAL—LOWER SURFACE	76·80	51·50
RIBS		11·52	13·78
FRONT AND REAR WEBS		31·80	56·26
	TOTAL—COMPLETE BOX	211·58	179·64

ITEM	No. OF PARTS RIVETED	No. OF PARTS INTEGRAL
UPPER SKIN	2	1
LOWER SKIN	2	1
STIFFENERS AND CHANNELS	44	
REINFORCING BRACKETS AND ATTACHMENT ANGLES	148	
SPARS — FLANGED WEB SHEET	6	2
WEB STIFFENERS	72	36
RIBS	15	11
RIB STIFFENING AND ATTACHMENT ANGLES	67	253
BOLTS, NUTS, WASHERS	1009	
RIVETS	7064	7051
TOTAL	10427	3355

ESTIMATED COST OF PRODUCTION

ITEM	RIVETED LABOUR COST £	RIVETED MATERIAL COST £	INTEGRAL LABOUR COST £	INTEGRAL MATERIAL COST £
ASSEMBLY OF SPAR BOX	700	8	460	5
UPPER SURFACE	800	46	360	91
LOWER SURFACE	800	45	360	93
RIBS	220	5	195	18
FRONT SPAR	83	6	36	6
REAR SPAR	62	6	36	6
DETAILS	71	3		
TOTALS	2721	120	1487	225
ESTIMATED TOTAL COST = £2841			= £1712	

SUMMARY

SAVING IN WEIGHT = 24·6%
SAVING IN No OF DETAIL PARTS = 63·1%
SAVING IN No OF ATTACHMENTS = 71·7%
SAVING IN COST = 39·8%

Fig. 17. Comparison between integral and riveted construction.

Because of the required spanwise tapering of the skin thickness, stringer thickness, height and spacing, it was considered impracticable to machine satisfactorily the flanged stiffener section, and hence unflanged stiffeners were adopted. In view of the small wing depth this was not inefficient structurally. **(2)** The minimum calculated dimensions of the sections along the span were reduced to straight tapers to facilitate machining, but in spite of this the minimum requirements for wing strength were very closely obtained, much nearer than would have been possible with riveted construction.

The box was 120 in. long and 22 in. wide at the root, tapering to 13.5 in. at the tip. The overall depth was constant at 10 in. and the outside surfaces had a constant contour conforming to aerofoil section. Summarising the sectional dimensions of the compression plank at the root and tip, the skin thickness tapers linearly from 0.275 in. to 0.056 in., the stringer thickness from 0.140 in. to 0.055 in., the stringer depth from 2 in. to 0.8 in. and the stringer spacing from 2.75 in. to 1.678 in. The root ends of the planks were flared out to provide a multi-bolt wing root attachment and this was reproduced at the tip ends to facilitate test rig attachment.

An analysis of weight, number of parts and cost in comparison with the conventional riveted construction is shown in Fig. 17. Savings of 25% on weight, 44% on detail parts 70% on attachments were achieved. These figures are based on actual experience with both forms of construction and it is estimated that the use of integral construction can effect a production cost saving of 39%, based on fifty aircraft (i.e. 200 machined planks). The actual machining time on the second plank produced compared very favourably with the estimated time allowed in this table for production.

Against this, the riveted box spar was originally designed for a "one-off" experimental aircraft and the cost comparison, therefore, should be regarded as an exceptional example.

Sequence of Machining Operations

The major part of the work involved the machining of the planks and the actual manufacture of the upper compression surface will be dealt with in some detail. The lower surface was slightly different dimensionally but was manufactured by identical methods.

The sequence of operations was planned to minimise distortion and was as follows:

(i) skin breaking on the original billet
(ii) cutting to rough shape on the band saw. The cut-away pieces were used for material control checks during the various stages of heat treatment
(iii) thickness tapering
(iv) contouring
(v) rough machining of the stiffeners and skin
(vi) stress relieving heat treatment
(vii) final machining of the stiffeners and skin
(viii) final machining of the end attachments
(ix) final age-hardening heat treatment.

During these operations close inspections were made at frequent intervals to check the distortion level and machining accuracy.

The Blank Billet and Preliminary Operations

The blank rolled billet was supplied by the Northern Aluminium Company, in a stretch-levelled solution-treated condition. The stretching operation was considered necessary to provide flatness and a more homogeneous metal flow in order to control and minimise distortion. The billet was 2 ft. wide, 10½ ft. long and 2½ in. thick and was in DTD. 603B. material which, after age-hardening, was to specification DTD. 646. In this condition figures of 27 tons/in.² ultimate, 21 tons/in.² proof and 5% elongation were guaranteed throughout the plate. Subsequent control test specimens showed that these figures were completely met and, in the outer skin, exceeded. The degree of flatness was remarkably good but it was necessary to exercise considerable

Fig. 18. Overall thickness taper machining on the Stirk planer.

care in the storage and support of the plates because of a tendency to creep under their own weight.

Three billets were ordered, each weighing 755 lb., the extra one being a safety measure against a mishap to one of the billets during its many adventures. Subsequent achievement showed that this precaution was entirely unnecessary.

The skin-breaking operations on the Stirk planer simply removed the outer 1/16 in. skin and provided machined reference surfaces for subsequent operations.

Rough cutting to shape was made on the band saw. Clamping lugs were provided for machining purposes while the plate was still solid and the removed portions were utilised for control test specimens to determine the longitudinal and transverse properties in the billet.

Taper and Contour Machining

The overall thickness taper, i.e. web height, was effected on a Stirk planing machine (Fig. 18), the plate being held down by the clamping lugs. To maintain symmetry and hence minimise distortion, taper was machined on both sides about the plate centre-line. This proved to be a wise precaution as after one side only had been machined, a considerable bowing occurred which disappeared on machining the remaining side. Hardwood angular blocks were used to set-up the required taper.

Fig. 19 shows the same planing machine also producing the aerofoil contour. Hardwood blocks were again used to set the surface to be contoured in a horizontal plane and contouring was effected by modifying the traversing head tool-box of the planing machine to follow a copy bar machined to the required male profile. Thus the cross feed automatically gave correct lift with each stroke. The tool used for the finishing cut was of the button type which produced an excellent finish.

Fig. 20. Suction bed employed for rough and final milling operation.

The Suction Bed and Rough Milling

For the rough milling and subsequent operations to form the webs and skin, it was considered necessary to employ a suction bed for clamping purposes. This bed (Fig. 20) was made with a soft "Remax" top plate and was contour machined in a similar manner to the methods described in the previous section, with the exception that a female copy bar was employed. The reverse contour so produced provided the bed surface on which the contoured billet could rest. This "Remax" plate was drilled with 200 small holes, interconnected by shallow grooves, which led into a sealed vacuum chamber. The chamber was exhausted by a 5 h.p. air-cooled vacuum pump capable of maintaining 29 in. of mercury, or effectively a 13.5 ton clamping force. This bed also served as an

Fig. 19. Contour machining on the Stirk planer.

indexing jig providing longitudinal angular movement for machining the tapered stiffener spacing. A number of experiments were made with thick sheets to determine the holding down power of the suction bed and these indicated that adequate suction was available to hold down the actual planks.

The suction bed was used on a Wadkin spar mill for the rough machining operation to form the stiffeners and skin. The clamping lugs were still used to guard against sudden failure of the vacuum pump during machining and all the edges were sealed to reduce leaks. The machining of the various channels was done progressively from the centre of the plank, indexing being necessary after each machine traverse to provide stiffener spacing taper. At this stage it was found that only 22 in. of mercury could be maintained from the suction pump, due to hollow spots and probable minor leaks. This was rather worrying as the existence of hollow spots would reduce machining accuracy. It was thought, however, that as the thickness of material was gradually reduced the plank would automatically pull down. This, in fact, occurred and the hollow spots disappeared during the final machining, the vacuum gauge then increasing to 28.5 in. of mercury.

Stress-Relieving Heat Treatment

Roughing cuts reduced the billets to within $\frac{1}{8}$ in. finished size and the next stage was the stress-relieving heat treatment. The thought behind this operation was as follows. It was considered necessary to finish machining in the actual, or near solution-treated, condition and then finally age-harden in order to avoid possible machining cracks. Before final machining, however, it was desirable to release any locked-up stresses induced by the removal of the massive elements of material during rough machining. The variation of ultimate strength with time for any given ageing temperature for most common light alloys shows that for the first half-hour or so there is very little change in strength or, in fact, even a slight reduction.

Since, therefore, the release of locked-up stresses is largely governed by temperature and not time, this phenomenon permits a stress-relieving operation whereby the component is raised to the age-hardening temperature as quickly as possible and rapidly cooled after a very short soaking time. After this treatment the material should then still be in the required solution-treated condition for final machining. It was thought that probably 90% of the total machining distortion would have occurred before this operation, as final machining would remove only a relatively small amount of metal. Also, since the material would still be in the solution-treated condition, large distortions could be corrected by cold working, or small distortions removed during the final machining.

For the stress-relieving operation on the plank it was considered necessary to constrain the plank between rollers, in an attempt to confine the nature of the distortion to longitudinal displacement and minimise cross-sectional distortion. Control test specimens were included from which it was discovered after the stress-relieving treatment on the first plank that parts had, in fact, been fully aged in half-an-hour or so at temperature. On the second plank, the time was reduced to about 10 minutes and lower strength properties were indicated, but in neither case have solution-treated properties been retained. However, as there was no measurable cross-sectional distortion and only a bow of 0.35 in. in 10 ft., it was decided to continue with the final machining of the stiffeners and skin.

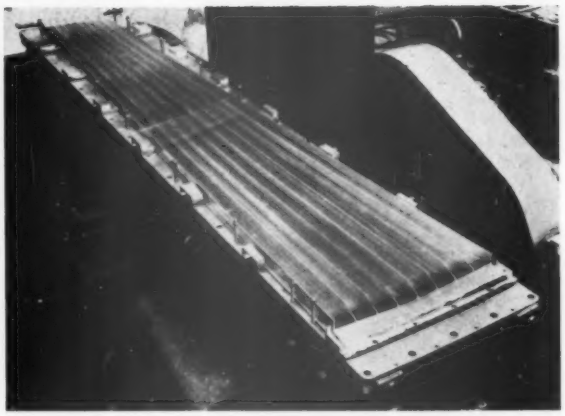


Fig. 21. Completed machining of the skin and stiffeners.

Final Machining

Figure 21 shows the skin and stiffener machining completed. Machining was again done on the Wadkin spar mill using the suction bed, which easily provided the necessary suction to pull out the small bowing previously mentioned. There was no appreciable increase in this bowing and it was quite easy to straighten the machined plank by thumb pressure. Finally, the ends were machined on a plano-mill and the complete flange artificially aged, the same constraining rig being used as for the stress-relieving operation. An inspection survey of the completed plank indicated that a general machining tolerance of + 0.004/—0.001 in. had been achieved, with a maximum of + 0.009/—0.002 in. This was rather more than the ± 0.002 in. called for and most of the increase was traced to machining deviations on the suction bed surface. As the weight agreed closely with estimate and the strength was subsequently proved, the achievement was quite satisfactory for a first effort, although better accuracy must, and would, be obtained in production.

The second plank was produced much more quickly after the experience gained on the first plank and was equally satisfactory. The final weights of the compression and tension planks were 57.5 lb. and 50.9 lb. respectively, which represents some 7% of the original billet weight.

Test Panels

Some useful experience has been gained during the preparation of test panels by and for the Bristol Aeroplane Company. The first series was made by them from a plank 4 ft. x 18 in. x 2¼ of Noral 75 S-W (i.e. solution treated) from which a panel 4 ft. long by 12½ wide with 5 stringers .142 in. thick and 1½ in. deep. The skin thickness was 0.10 in. and the radius of the fillet between skin and stringers was ¼ in.

The whole job was done on a Wadkin spar miller which only permitted a limited amount (4 in.) of adjustment across the bed. The plank was first milled to finished thickness of 1.5 in. by taking off equal amounts from each side. The single cutter was set up five times on the arbor, one setting for each stringer, the section being machined to within 0.05 in. in this way. The panel was then taken off, heat treated and set up on the bed again. A further five settings were necessary to finish-machine to final size.

This was followed by two thinner panels, the thickness of stringers being 0.06 in. and of the skin 0.09 in. The fillets were reduced to 3/16 in. on the one panel and 3/32 in. on the other.

Both planks were first reduced to 1¼ in. thickness on a planer, removing equal quantities from each side. The job was then set up on the same Wadkin spar miller as before. In view of the small stringer thickness of 0.06 in. it was decided to gang mill, and this was done using six settings of the cutters on the arbor, machining to within 0.05 in. as before.

The plank was then removed, heat treated, and set up again, a further six settings being required to machine to size.

Recently, two more test pieces have been made for the Bristol Aeroplane Company by Armstrong Whitworth Aircraft Ltd. Each panel was machined from a billet of Noral 75 S-W which was 6 ft. x 1½ ft. x 2¼ in. thick in solution treated condition.

The two billets were first placed on the bed of a planer as shown in Fig. 22 and cleaned up on one face producing a flat surface to work off. It was then transferred to a Wickman spar miller, where two test pieces were sawn off it along its length and the two edges machined to give the correct width plus 0.25 in.

Fig. 22. Billets for B.A.C. panels being cleaned up.

The billet was then put on the Onsrud spar miller and strapped down with the flat face on the bed enabling the channels to be roughed out leaving 0.25 in. on all faces. This was done using a 2.5 in.

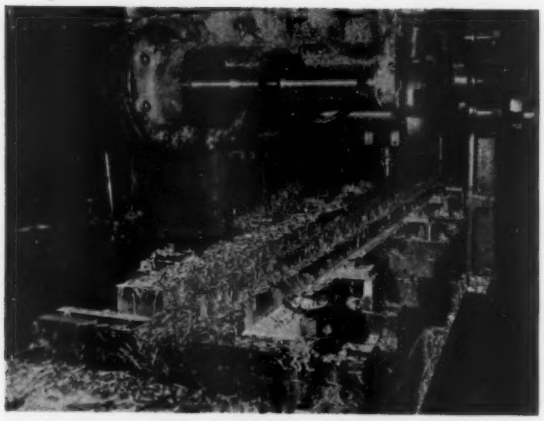


Fig 23. Rough machining of channels on Onsrud milling machine.

Fig. 24. Two-fluted carbide tipped cutter for rough machining channels.

Fig. 25. Finishing the outside face on the 48-168 Hydrotel.

diameter two-fluted carbide tipped endmill running at 10,000 r.p.m. The 0.25 in. left on all faces was to allow for machining out distortion.

This proved to be necessary because, after unstrapping, the distortion lengthwise was in the region of 0.040 in. The panels were then returned to the planer, placed on a flat face, packed up each end 0.040 in. and the tops of the channels resurfaced. They were then turned over and the flat face and edges remachined. The channels were then re-cut on the Onsrud, bringing the dimensions down to plus 0.0625 in.; this time the distortion was kept to within 0.015 in. Fig. 23 shows this operation on the Onsrud high speed milling machine and the two-fluted carbide tipped cutter used for rough machining the channels is shown in Fig. 24.

Precipitation treatment was then carried out at 135°C for 12 hours, after which no new distortion had taken place.

To carry out the final finishing operations, the panels were transferred to a Cincinnati 48-168 Hydrotel with the vertical head attached, the spar being clamped in four vice-jaws with blocks to support the flanges. By using a 14 in. diameter face mill the top face was finished off. This is illustrated in Fig. 25. In order to finish mill the channels a vacuum chuck was used, and without any other clamping and using 23 to 27 inches of mercury, sufficient grip was obtained to finish machine the channels and face thickness. The final operation is shown in Fig. 26.

Fig. 26. Finishing the stiffeners and inner skin surface on the 48-168 Hydrotel.

Fig. 27. The centre section and inboard portions of a tailplane spar flange produced from a casting.

Cast Wings

Investigations show that there is a possibility that future wings for very high speed aircraft may be designed from purely stiffness considerations and that the flight loads will permit the use of lower grade material. The possibility of casting wings should therefore not be neglected. The advantage in the elimination of removal of large quantities of metal is obvious and the development of shell moulding techniques is of considerable interest in this field. Casting also has considerable attraction in producing spar elements of a form difficult to machine as shown in Fig. 27, which shows the centre section and inboard portions of a swept-back tailplane spar flange produced from a low grade alloy for demonstration purdoses. The possibility of having to machine only the outer contour of such a part has obvious advantages.

Contour Milling

There is one point on which all investigators are in complete agreement and that is the vital necessity for a contour milling machine. Many proposals have been made, of which two are described. So far all designers are agreed that they may be based on the principle that the surface of the wing may be described by straight line generators and therefore lies on the surface of a particular oblique cone.

It is interesting to reflect that the surfaces of both swept and delta wing forms with straight taper also lie on the surface of their own particular oblique cone, and that they could therefore be equally well machined for external contour by a similar process.

The form of machine tool equipment proposed by Boulton Paul Aircraft is shown in Fig. 28 and is essentially a milling machine, the cutter of which is constrained to move successively along the straight line generators of the main wing component which constitutes the workpiece.

The beam carrying the cutter is supported on end pillars, being universally pivoted to the pillar at one end and able to slide through the other pillar while at the same time being supported by it.

The beam carries a lead screw, along which the milling cutter assembly is constrained to move in such a way that the periphery of the fly cutter traverses a spanwise conical generator of the actual wing surface which it is required to machine. The pillar supports of the beam are, in turn, carried on runners or pads which are free to slide in a chordwise direction on cam profiles. These cams, for the biconvex wing section under consideration, take the form of circular arcs, and are of such dimensional relation to the position of the workpiece on the milling table that progressive indexing of the beam in a chordwise direction sets the milling cutter for a succession of spanwise traverses to give the required wing contour. The finished contour is thereby defined by a sequence of flat facets and, by selecting the cutter width in relation to the curvature of the wing section, it can be arranged that the machined contour lies within prescribed limits of accuracy. For instance, in the case of the present wing a cutter width of 2 in. indexed chordwise by 1 in. for each successive spanwise cut, would produce a section contour such that the intersection of adjacent facets is not more than 0.0004 in. outside the true

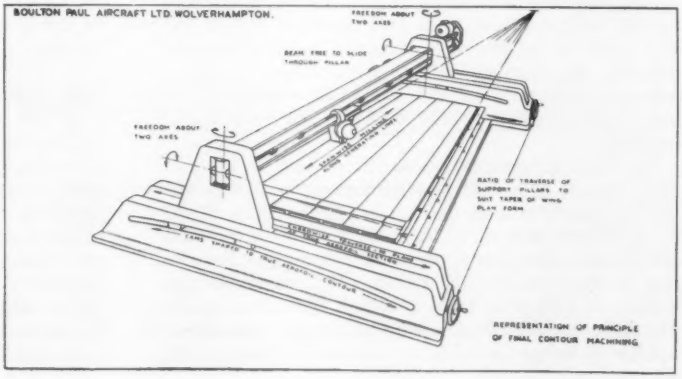

BOULTON PAUL AIRCRAFT LTD. WOLVERHAMPTON.
FREEDOM ABOUT TWO AXES
BEAM FREE TO SLIDE THROUGH PILLAR
FREEDOM ABOUT TWO AXES
RATIO OF TRAVERSE OF SUPPORT PILLARS TO SUIT TAPER OF WING PLAN FORM
REPRESENTATION OF PRINCIPLE OF FINAL CONTOUR MACHINING

Fig. 28. Contour milling machine proposal

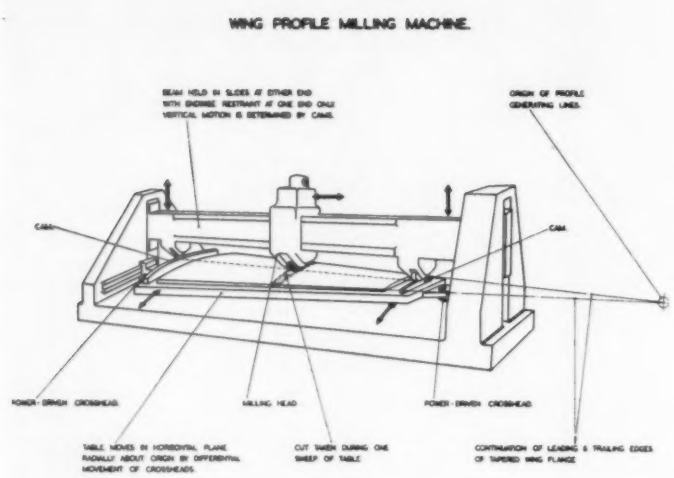


Fig. 29. Skin miller (A.W.A.).

contour. No subsequent planishing of the surface is therefore necessary and the wing component is complete once the two surfaces have been machined in this manner.

Such a machine as has been described can be applied to the contour machining of wings of any combination (within its dimensional range) of plan form, taper ratio, thickness-chord ratio and aerofoil section. It could also be arranged to machine the wing elements themselves prior to assembly one to the other. If the wing skin thickness were to be reduced to a degree where chordwise supporting ribs became necessary, then, for internal machining, the cutter in the course of its spanwise traverse could be programmed to give an intermittent vertical movement. Perhaps the easiest task which a machine tool of this nature can accomplish is the milling of thin integrally stiffened sheet from slab material.

The A.W. proposals covered by Patent No. 12391/52 incorporate the additional principle of rotating the work about a virtual centre which is in effect the point of the cone. It avoids the effect of the flat facets referred to above, because milling is carried out chordwise and the surface of the cylindrical cutter is at all times on a straight line generator.

The objective of the A.W.A. machine is to produce smooth wing surfaces from slab material by the use of a milling cutter of substantial width, thereby reducing the number of sweeps to traverse a given area to a minimum. Furthermore, the machine is to ensure an accurate profile without requiring hand finishing.

The normal geometry associated with a tapered wing consists of a root and tip section with straight line generators joining corresponding fractions of the chord at each section. If, then, the line of contact of a cylindrical cutter lies along these generating lines in turn, a true surface will result. Fig. 29 shows the method of achieving this, in which the workpiece is held down on to a block which has a flat undersurface capable of being moved in a horizontal plane on the machine bed. The screws at either end which perform this movement can be driven at different rates dictated by the plan-form taper ratio, so that the wing rotates about the centre of the generating lines.

Running spanwise above the wing is a beam carrying the cutting head with screw feed to progress the cutter at the end of each chordwise sweep. The angle and height of this beam is regulated by cams at root and tip which move with the work and so synchronise the cutter and workpiece movements. These cams are, of course, nothing more elaborate than plates shaped to the extended wing profile, and in a full-scale machine would probably transmit movement to the beam *via* hydraulic means. The contact lines of the two rollers and the cutter are always in the same straight line and will at all times correspond to a straight generating line in the wing profile.

This machine is capable of considerable development for purposes other than already outlined; for example, by an alteration to the milling head the cutter can be made to move spanwise along the beam and so form the integral stiffening required on the inside of a wing flange. Heavy ribs made from forgings could be machined to profile, and, of course, the blocks to which the workpiece is clamped may be machined on it. A very successful working model has been made and is illustrated in Fig. 30.

Spar Root End Fittings in H.T.S.

In the new high speed aircraft the use of steel forgings for spars and spar fittings is becoming very common, bringing with it many machining difficulties and problems. Firstly, a revision of machines is required, that is, higher horse-power with lower speeds and lower feed rates, as against the past when the emphasis was on higher speeds and feeds for the cutting of light alloys. Additionally, due to design, the number of operations is increased, and a large proportion of these call for the use of machines equipped with tracer control mechanism.

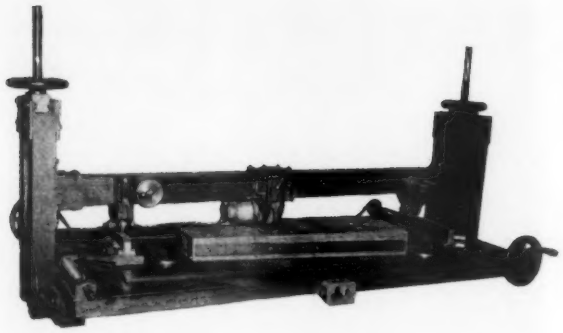


Fig. 30. Working model of skin miller (A.W.A.).

This is fully shown by the typical pair of spar root end fittings shown in Fig. 31 which has a total of 34 operations. Apart from two drilling and one grinding operations, the remaining 31 are split into 12 on plain type of milling and 19 which have to be processed by tracer-controlled mechanism. It can also be seen from the chart (Table 2) that 11 of these are operated on 56/90 Duplex machines which accommodate two spars at once. A routing chart showing the sequence of operations on the various machines is shown in Fig. 32.

A large amount of metal removed is also necessary. In this particular case the weight of the forging is 150 lb. and when completely machined down is reduced to 50 lb.

The material from which the part is made is S98, a 75-ton nickel chromium steel with Brinell Hardness of 341-388 and all machining is carried out in the hardened condition. It might be noted here that the slight difference in hardness can be quite noticeable in different batches of forgings which can cause certain operations to take longer, so throwing out of gear the line production of a spar of this type with so many operations. It is also seen from the chart that all the final finishing operations are preceded by a roughing cut to relieve internal stresses, as it was found that the boom distorted on the average 0.050 in. in the vertical and horizontal planes.

Whilst investigating the machining of this boom, extensive investigations were carried out to find the best type of cutter, including carbide tipped, negative rake, and inserted blade alternate angle high speed cutters.

The investigations proved that it was impossible on the types of machines 56/90 and 4/48 Cincinnati, where the tracer control mechanism is functioned by

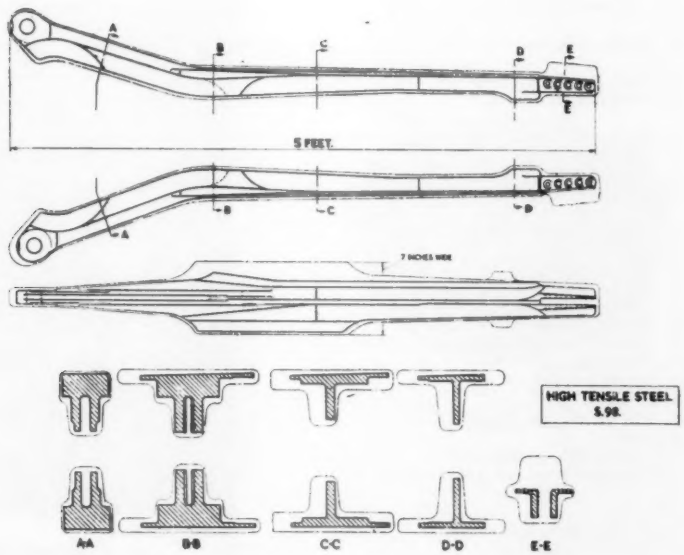


Fig. 31. H.T.S. spar root end fittings.

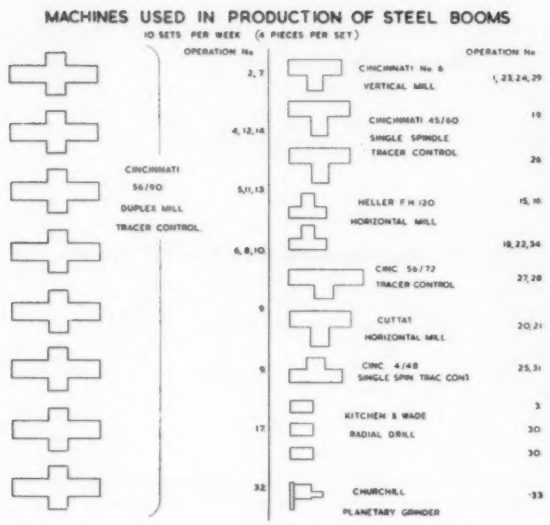


Fig. 32. Routing chart H.T.S. spar root end fittings.

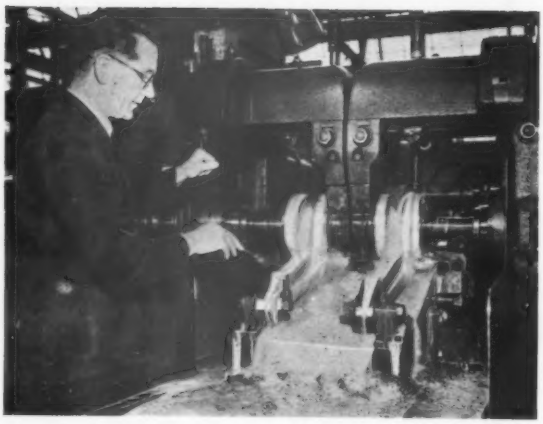


Fig. 33. Operation No. 4 on H.T.S. spar root end fitting.

TABLE 2

SPAR BOOM—S.98

OP.		*Machine*	*Cutter*	*R.P.M.*	*Feed*	*Lubricant*	*B.H.P.*
1	Rough mill base to 11″ start of rad. remove approx. 0.1	Vertical Cin. No. 6	12″ dia. carbide negative rake	68	6″ per. min.	Dry	50
2	Rough mill eye to 1.6 ± 0.003	56/90 Duplex T.C.	14″ dia. cutters	13	$\frac{3}{8}$″		25
3	Drill and ream 1-$\frac{1}{4}$″ tooling hole and 1-$\frac{3}{8}$″ in lug.	Radial arm					25
4	Rough straddle mill leaving 0.075 on all dimensions	56/90 Duplex T.C.	8″ dia. alternate angle H.S.C.	13	$\frac{3}{8}$″		25
5	Rough mill both sides of fin, leaving + 0.075	56/90 Duplex T.C.	8″ dia. alternate angle	13	$\frac{3}{8}$″		25
6	Rough mill top of fin. leaving + 0.075	56/90 Duplex T.C.	6″ x 2$\frac{1}{2}$ H.S.C.	18	$\frac{3}{8}$″		25
7	Rough base of neck	56/90 Duplex T.C.	6″ x 6″ (3 cutters inter-locked to give 6″)	18	$\frac{3}{8}$″		25
8	Rough mill slot in fin (.375 wide)	56/90 Duplex T.C.	6″ x $\frac{3}{8}$″ H.S.C.	18	$\frac{3}{8}$″		25
9	Rough mill both edges end to end	56/90 Duplex T.C.	4″ dia. 6″ long (Roller Mill 20° Helix angle Fine Tooth Series)	19	$\frac{3}{8}$″		25
10	Finish mill top of fin	56/90 Duplex T.C.	6″ x 2$\frac{1}{2}$ H.S.C.	18	$\frac{3}{8}$″		25
11	Finish straddle mill fins	56/90 Duplex T.C.	8″ dia alternate angle H.S.C.	13	$\frac{3}{8}$″		25
12	Finish mill 0.512—0.507 slot	56/90 Duplex T.C.	6″ dia. super high speed	18	$\frac{3}{8}$″		25
13	Finish mill 0.265—0.200 slot	56/90 Duplex T.C.	7″ dia. H.S.C.	18	$\frac{3}{8}$″		25
14	Finish straddle mill sides	56/90 Duplex T.C.	8″ dia. alternate angle H.S.C.	13	$\frac{3}{8}$″		25
15	Finish mill 5.0 rad. to blend	Heller	10″ dia. H.S.C.	20	$\frac{3}{8}$″		30
16	Finish mill 39″ tail end	Heller	10″ dia. H.S.C.	20	$\frac{3}{8}$″		30
17	Mill 19″ step section to run out at fork	56/90 Duplex T.C.	6″ dia. H.S.C.	18	$\frac{3}{8}$″		25
18	Mill step	Heller	Carbide tipped cutters	80	5″	Dry	30
19	Mill step on taper and top of flange	45/60 S.S. T.C.	10″ H.S.C.	16	$\frac{3}{8}$″		25
20	Finish mill eye	Cuttat	12″ dia. H.S.C.	13	0.3		25
21	Mill chamfers	Cuttat	6 dia. H.S.C.	20	$\frac{1}{8}$″		25
22	Plunge mill 6″ rad.	Heller	12″ dia. H.S.C.	20	$\frac{3}{8}$″		25
23	Finish mill base up to base of neck	No. 6 Vertical Cinc.	8″ dia. carbide	75	5		50
24	Finish mill base of fork	No. 6 Vertical Cinc.	8″ face mill	14	$\frac{3}{8}$″		50
25	Straddle mill end of fin and top of fork	4/48 S.S. T.C.	7″ dia. H.S.C.	18	$\frac{3}{8}$″		25
26	Finish mill sides of fork	4/48 S.S. T.C.	10″ dia. H.S.C.	13	$\frac{3}{8}$″		25
27	Rough mill slot	56/72 S.S. T.C.	16″ dia. wide H.S.C.	10.6	$\frac{1}{4}$″		25
28	Finish mill slot	56/72 S.S. T.C.	16″ dia. 0.670 H.S.C.	10.6	$\frac{3}{8}$″		25
29	Mill 45° chamfer on side of slot	Vertical No. 6	1″ dia. endmill	70	$\frac{1}{2}$″		50
30	Drill	Radial					
31	Produce rads. on fork end	45/60 S.S. T.C.	Semi Concave Cutter				25
32	Finish profile on neck and around 1$\frac{1}{4}$″ hole	56/90 Duplex T.C.	4″ dia. 8″ long 20° Helix Fine Tooth Series	18	$\frac{3}{8}$″		25
33	Planetary grind hole 1″ dia.	Churchill Planetary					25
34	Remove tooling lugs	Heller	Side and Face Cutters				30

(Edgar Vaughan Antiseptic Water Soluble)

(Edgar Vaughan Antiseptic Water Soluble)

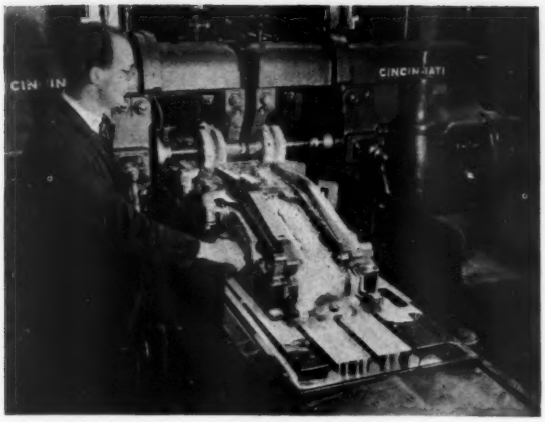


Fig. 34. Operation No. 5 on H.T.S. spar root end fittings

hydraulic means, to use the climb milling techniques necessary with carbides, due chiefly to the feed of the table being insufficiently rigid. It was therefore necessary to dispense with carbides for these operations, but it was found economical to use inserted blades and, in some cases, alternate angle cutters.

The investigation also proved that it was policy to regrind these cutters after a fixed number of parts had been operated—this number varied with the different operations. Three arbors were provided for each machine, one set in use, one set on re-grinding and the third assembled and pre-set ready for replacement. Figs. 33 and 34 show Operations 4 and 5 of this type of machine and Fig. 35 shows the cutters mounted on an arbor.

For straight milling, the use of carbide with negative rake was found satisfactory, and it was

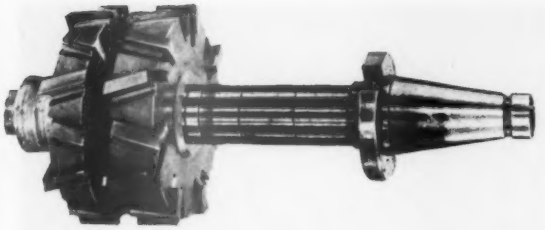


Fig. 35. Inserted blade cutters mounted on an arbor.

quite possible to use cutter speeds of 80 r.p.m., with a feed of 6 in. per minute with no coolant, which gives a 6 thou. per tooth lead.

In operating this on a Cincinnati No. 6 Vertical on the first operation, a 12 in. diameter inserted blade *carbide* tipped cutter with negative rake was used at a speed of 68 r.p.m. and a feed speed rate of 6 in. per minute, and found to be satisfactory. The motor was 50 B.h.p. A check made during this operation showed that 35 B.h.p. was being used. Fig. 36 shows this operation in progress and Fig. 37 illustrates the tool used.

It can also be seen from the chart that carbides were used in Operation 18 on a Heller, the operation being side milling, and it was found possible to use 80 r.p.m. and 6 in. feed roughing, and for finishing 100 r.p.m. and 16 in. per minute feed.

The investigation also showed on Operation 9, where a thin section requires machining and where the cutter has to have a depth of cut up to 1½ in., the use of a slower helix angle of 20° was more suitable than the standard quick spirals.

The general lubricant used is Edgar Vaughan Antisept. M. except for the carbide which is dry, but the use of Esso TS.404 has proved as satisfactory.

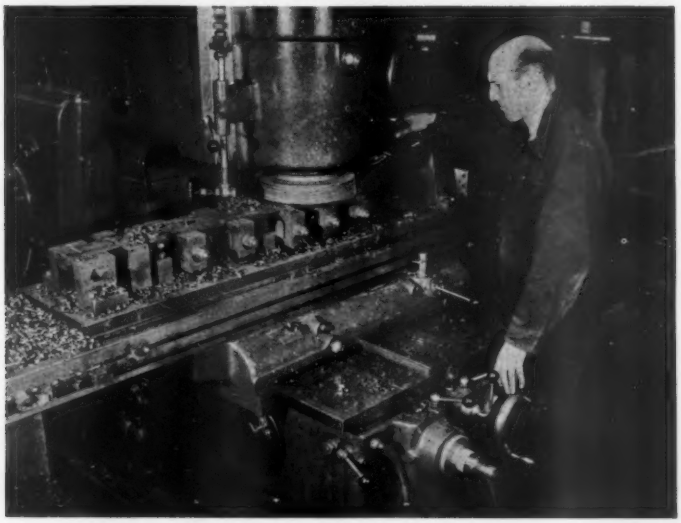


Fig. 36. Operation No. 1 on H.T.S. spar root end fitting.

Fig. 37. Tool used for Operation No. 1.

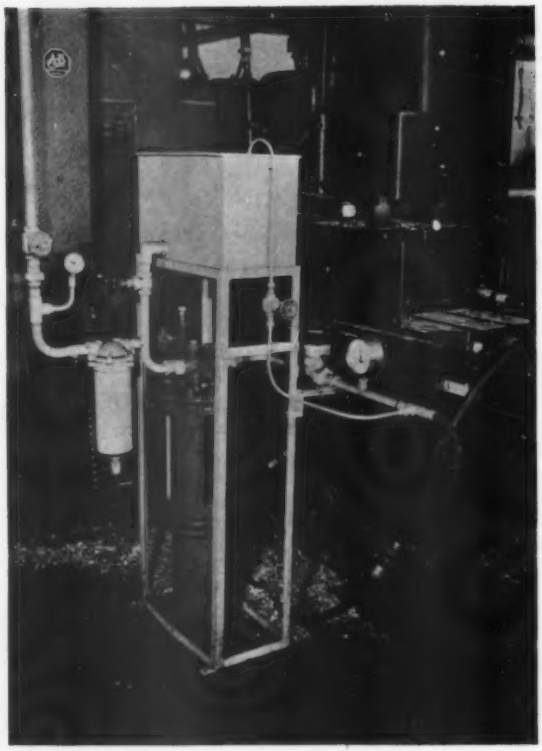


Fig. 38. Air-hydro pump supplying power to hydraulic clamps.

For fixtures during the machining of the boom where heavy cuts take place, hydraulic clamping is used, and it has been found by fitting an air hydro pump to the machine working off the works air line, a very efficient and economical method of hydraulic clamping is effected. The unit is shown in Fig. 38.

Undercarriage Beam (L.A.)

An undercarriage pivot bracket made from a Class 1 stamping in DTD.683 (see Fig. 39) has a total number of operations of 58, made up of 15 horizontal and six vertical milling, three boring, nine Hydrotel and 25 drilling. It is noticeable that the drilling and boring take up approximately 50% of the machining; also, as these are the last operations in the process, accurate and reliable drilling and reaming fixtures are required to prevent scrap and so avoid rendering the material and the previous 28 long machining operations useless. It can also be added that many adaptations to normal drilling machines are required to ensure accurate drilling, reaming and pin-facing to be carried out in inaccessible locations. One of these fixtures that was necessary for the pin-facing of holes on the inside face of this part is shown in Fig. 40. The cutters used are standard for light alloy machining, that is 12 in. diameter carbide tipped face mill for the side faces running at 800 r.p.m. with a feed of 5.8 in. per minute and a standard 2 in. endmill for the internal vertical milling operations on the Hydrotel.

The forging is first rough machined all over, removing approximately $\frac{1}{4}$ in. of metal to relieve stresses, Two of these operations are shown in Figs. 41 and 42. showing roughing cuts being taken on outside and inside surfaces respectively. It was found necessary to drill and ream two 5/16 in. holes (Operation 2) and later in Operation 14, that is, after the roughing, to re-drill and ream these holes to $\frac{3}{8}$ in. to correct any errors that may have occurred during the roughing operations. From these tooling holes all measurements and angles are taken by Inspection.

The boring of the pivot bracket is carried out on an Excello boring machine, using micro-bores which can be set and adjusted to 0.0001 in. The first operation is roughing one bore and finish facing the other, the second is repeating the same operation on the other end and the final one is to complete the bore. This process is illustrated in Fig. 43.

The completed part is then sent for anodic treatment, and afterwards left 48 hours before crack detection.

Conclusion

Considerable progress has been made in this country of recent years in the field of integral construction but, in the opinion of many, progress is still too slow on some aspects of the problem. This Paper has attempted to summarise some of the work done and to highlight some of the deficiencies still evident. It is known that much valuable work is being done other than that specifically referred to and it is hoped that the discussion at the Conference may be the means of adding to the general fund of information on the subject.

Grateful acknowledgements are made for the very generous assistance given by Mr. Keith-Lucas, of Short Bros. and Harland Ltd., by giving permission to use extracts from Ref. 2; also to Mr. Crocombe, of Boulton Paul Aircraft Ltd., for his assistance and permission to refer to his skin miller. The Authors also gratefully acknowledge the permission of the Royal Aeronautical Society to use extracts from Refs. 1 and 2 and for their help in lending the blocks for the illustrations used from these Papers. Finally, the authors wish to thank Sir W. G. Armstrong Whitworth Aircraft Limited for permission to write this Paper and to acknowledge the help given by their colleagues at the firm in its preparation.

References

1. "Integral Construction—Its application to Aircraft Design and its effect on Production Methods", by E. D. Keen, B.Sc.(Eng.), F.R.Ae.S. —*J.R.Ae.S.*, April 1953.
2. "Integral Construction—A Survey and Experiment", by K. L. C. Legg, D.C.Ae., B.Sc.(Eng.), A.M.I.Mech.E., A.F.R.Ae.S.—*J.R.Ae.S.*, July 1954.

The Discussion on the two Papers presented in Session II appears on pages 180 to 188.

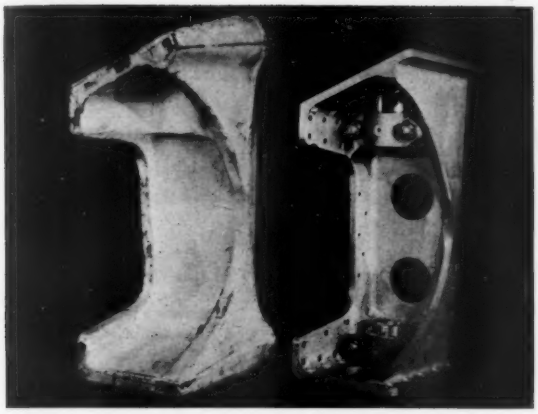


Fig. 39. Undercarriage pivot bracket.

Fig. 41. Roughing cuts on outside of undercarriage pivot bracket.

Fig. 43. Boring of undercarriage pivot bracket.

Fig. 40. Drilling attachment for pin-facing of holes in undercarriage pivot bracket.

Fig. 42. Roughing cuts on inside of undercarriage pivot bracket.

JOINT DISCUSSION - SESSION 2

Chairman: R. S. BROWN, M.I.Prod.E.,

General Manager (Aircraft), Aircraft Division, Bristol Aeroplane Co. Ltd.

Mr. E. D. Keen, after reading the Paper, said that Mr. Vines had mentioned that morning the dilemma of who was going to put in the machinery to deal with the raw materials. There was, however, another dilemma or curious situation which had developed in connection with the question of integral construction. He thought it was axiomatic that one could design anything on paper, but could not tell whether it would work until one had tried it. There were two kinds of firm. There were those who had their own aeroplane in production, but there were also those who were not so well placed, and who had more time for research of the sort he had been describing. The dilemma was that the firms who had more time for research had not an aeroplane to which to apply it, and there had been a great tendency to say: "We shall not do anything unless it is of practical use today".

If an aeroplane was in production, it was very difficult to break off and start a new type of construction. His plea was that those who had the time should keep on with what might be called pure research, regardless of whether it was of immediate application. The Meteor tailplane referred to in the Paper was a good example of that. They had no delusions about what they had done being a better way to make a Meteor tailplane, but it had taught them valuable lessons. He thought that any sort of proposal which added to the general fund of knowledge should be given sympathetic consideration. Otherwise, when putting in a tender for a new aeroplane someone would ask: "Are you going to make it out of integral construction?" and the reply would have to be: "How can we? We have not the machines". Those machines could have been developed by doing fundamental research, regardless of whether it went on a particular part of the aeroplane.

Professor J. V. Connolly, B.E., F.R.Ae.S., M.I.Prod.E., (*The College of Aeronautics, Cranfield*) congratulated the Authors of the two Papers on their major contributions, which were very useful from every point of view. He wished to make a few remarks about the broad picture of integral skin construction and the whole problem which had to be faced. He thought that there was a tendency to be a little complacent about the whole question of progress on the production side of aircraft engineering. They had got into the habit of accepting as an ordinary matter of course the spending of tens of millions of pounds on research and development, but they boggled at providing the elementary tools of the trade for the production engineer. Mr. Keen's point about frittering money away on many standard machine tools, while raising difficulties about providing a single big machine, presumably because that big machine cost a large sum of money which required sanction at a higher level in the Ministry than the smaller ones, seemed to be a typical fallacy in this field.

Those who had tried to machine skins would realise that the skin milling machine was only one of the problems. There was a ready-made instrument in the form of the Hydrotel, for example, to do the work, but that machine was clearly by its nature the wrong one. In the first place it had been designed to cut hard materials, and consequently it was inherently much too slow and more costly than need be to cut an aluminium skin. Mr. Radcliffe's lecture would indicate what he meant.

Aluminium alloys could be cut at colossal speed, and fortunately they were indifferent to whether they were cut in the fully-treated state or annealed. This made no measurable difference to the cutting tools or machine-tool loads, but it made a great deal of difference to the distortion. He would like to emphasise strongly, however, the necessity to have those pieces of machinery which were required to do these jobs properly.

This country was very much behindhand in regard to having a really big forging press. A 50,000 ton press should be thought of. Exactly who should produce that press was open to discussion, but in the national interest there should be at least one available in the U.K. If they were going to use milled slab construction, and unless they were prepared subsequently to stretch-form the whole part, then they must have available a stretch-levelling press for the billets after manufacture from rolled or forged material. This would eliminate distortion after machining.

First of all, it was necessary to have adequate means of making the large billets, and preferably shaping the slabs as closely as possible to the finished shape by forging. Next, before using the slabs, it was necessary to put a few per cent. of stretch into them after they had been finished and heat treated to keep them flat. Thirdly, whatever might be needed in the way of machine tools to do the job must be available. He had indicated that he did not think that for aluminium alloys the contouring machine which was required was, in fact, a die-making machine; it should be an *ad hoc* development.

One of the factors which probably inhibited the taking of the necessary action was that integral skins had been thought of in this country for fighters rather than for commercial aircraft. Therefore, there was a great deal of uncertainty whether skins of light alloy would be used or whether machining of titanium or stainless steel would be the problem. That raised the question of whether the device used for machining should be suitable both for the light alloy and for the harder materials. He did not think that was really a matter of great importance, because he could not visualise civil air liners being manufactured out of titanium for some time to come, and there was clearly a necessity for skins — and big skins — to be machined for civil aviation purposes.

So far the discussion had been concerned with the stretch-forming of parallel skins, skins with equal cross-sectional area throughout their length. This was the most straightforward job, but at Cranfield they had done some research last year into the question of stretch-forming a heavily tapered skin. They had managed to do this (on a small scale) quite successfully, and in a way which was capable of extension to a bigger scale. The skin dealt with had to be within the capacity of the machinery at Cranfield (about 3 ft. x 6 in.), but the problems were not severe at that size and would not be severe up to three or four times that size.

A suction plate (or vacuum chuck) was used on which to machine the skin. This did not differ appreciably from those commonly known. Originally they had thought that there should be holes all over the surface, but this was unnecessary. For thin skins it was highly undesirable, because the holes were pushed through by the milling cutter down pressure and there was a "polka dot" surface which was

Fig. 1

undesirable. They used a plain ground surface plate with a little channel round the edge outside the machining area and a hole leading into the channel for the vacuum. That was adequate and there was no need to bother about holes, so long as the whole of the outside area was connected to the suction.

Fig. 1 showed the panel which was produced; this had about twice the cross-sectional area at one end that it had at the other, and it had double curvature, i.e., it was three-dimensional. Inherently it was a fairly difficult panel to produce. It did not have any flats, and was as good as any stretch-formed panel of parallel shape would be. It was made from L.1 alloy and the percentage permanent elongations were between 4 or 5% in total at any point. A Hufford type of press was used, with the device illustrated in Fig. 2 as an addition. There was an arm carrying an hydraulic jack and a roller or pad — it was a roller in the case shown, but it could be a pad — which had the curvature of the face of the final outside surface of the skin. It was a circular arc in the case shown, but it could be of any form desired.

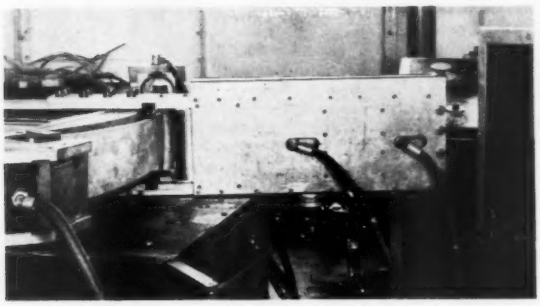


Fig. 2

The procedure was to bring the straight panel tangentially to the forming block and increase the strain at the smallest end to what was required, for instance, 4 - 5% permanent elongation. By varying together the increasing pressure of the vertical jack and the rate of rotation and load of the other (which was purely a mechanical problem) there was a gradually increasing reacting load provided from the vertical jack force, and the panel was formed without unequal stretch. The rolling device with fairly high vertical pressure was advantageous to the finish of the whole panel and avoided the question of flats. This had been purely an experiment; the panel had no significance in itself, but showed that by this, or some similar method, it was possible to make panels which were not uniform in cross-section.

Finally, in connection with the suggestion that they should go ahead with some big machines, in Professor Connolly's view it was not necessary to wait for a machine to be bought from America. The production machine bought from America, or which might be built in this country, might turn out, say, six panels an hour, but if one were content with one or two a day one could use a different sort of approach. With a welding torch, some rolled steel sections, concrete and a few hydraulic jacks, much could be done if the attitude of mind was right.

Mr. K. L. C. Legg, B.Sc.(Eng.), D.C.Ae., A.M.I.Mech.E., A.F.R.Ae.S., *(Structural Development Engineer, Short Bros. & Harland Ltd.)* said he did not propose at the present stage to elaborate on what had been said about the project at Short Bros. & Harland, unless any questions were directed to him on the subject. There were many comments which he would like to make, but he proposed to confine his remarks to what he considered to be the two most important aspects of integral construction. In so doing he would be repeating what others had already said, but he made no apology for that at all.

The first factor which he wished to mention was indicated in Fig. A. This was a roller-levelled slab 10 ft. long by 2 ft. wide, and it was machined to an unflanged type of integral construction and supposed to be flat. Fig. 21 of the Paper presented by Mr. Keen and Mr. Menzies showed what happened when it was stretch-levelled. The distortion on this was of the order of $\frac{1}{2}$" to $\frac{3}{4}$" at the thin end, which could easily be pressed down with the thumb and sprung into position.

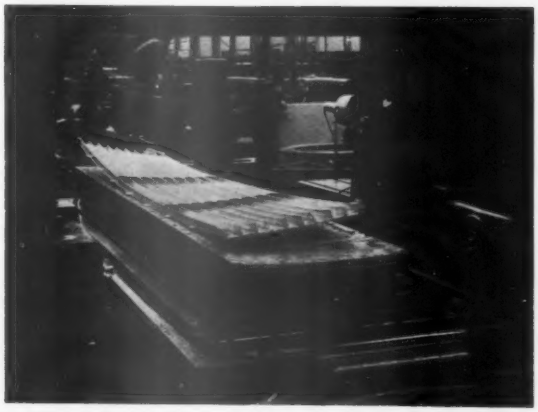


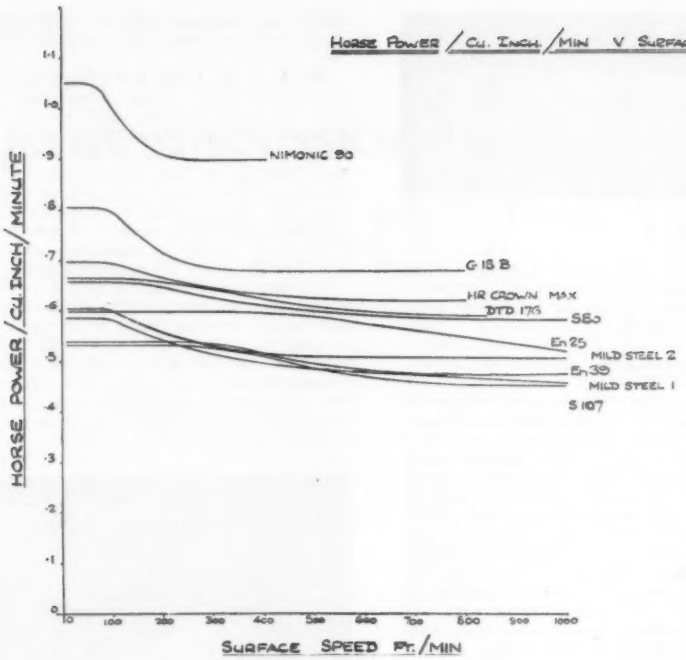
Fig. A

To Mr. Legg's knowledge, for the past three or four years discussion had raged, both publicly and privately, on the demand for large machine tools and the provision of adequate stretch presses to produce the initial billets. The need for the latter, he thought, was well proved by the example which he had just shown. They must have a stretcher press and have it quickly. Even if the decision to have it were taken that day, his information was that it would not be obtainable for another two years, which meant that they were already a very long way behind.

With regard to machine tools, the same arguments applied. He had already pointed out that the cost problem involved there was not so great as was often asserted, and therefore they must also have the machine tools.

There was one point which he wished to raise with regard to forgings. He very much favoured the use of large forgings for integral structures, but the main problem there, as he saw it, was obvious; they were limited on forging capacity and had not a large enough forging press in this country to deal with anything like reasonable areas of integral construction. He would like to ask Mr. Richards, therefore, whether there was any hope of the forging pressure which he had quoted, of 20 tons/sq. in., being reduced. In Mr. Legg's view, the logical first line of development was to reduce that pressure as much as possible.

Again, on the question of forgings, he would like to know whether copper-bearing alloys of aluminium could be forged more easily than the zinc alloys. He asked that question because a great deal of emphasis had been placed



so far on the zinc alloys such as 687 and 683, but at Short's they believed that the right material to use for the sort of application shown on his slides was DTD.646. There were several good technical arguments why that should be used, the main one being that the copper alloys were far better at moderately high temperatures than the zinc alloys.

Mr. W. S. Hollis, B.Sc.(Eng.), A.F.R.Ae.S., (*Assistant Director, Aircraft Production Development Branch, Ministry of Supply*) said that Mr. Keen had suggested a new term for the manufacture of one-piece structures — integrated structures. Many of them had spent a long time considering this method of aircraft construction, and had referred to it as integral construction. It would be just to say that Armstrong Whitworth had given longer and more consideration than most of the firms in the U.K. Perhaps while they were still struggling with integral as a new term of construction they had reason to believe they had completed the integration. He would like to pay a tribute to the exploratory work they had done.

He was interested to learn that the object of the early patent was to provide a method of simple and quick construction. Judging by current wing structures, the designers were prompt in removing the illusion that anything could be simple or have rapidity as an object. It was right, however, to press manufacturing resources to the utmost in achieving improved performance.

Alternative forms of construction which avoided riveting had been explored and were attractive for certain wing plan forms, but the attractions of design refinement, weight reduction, cost reduction, and reduction of progressing and planning of the component parts otherwise involved were achieving recognition for integral construction now in a manner that did not exist two years ago.

The balance between aircraft orders and the strategic importance of having plant and equipment available, although the orders might not warrant it, needed consideration. It could be said that the U.K. could feasibly consider:-

1. a 10 ft. wide rolling mill with taper facilities;
2. stretch levelling presses;
3. heat treatment and transfer plant to deal with longer slabs;
4. wing aerofoil generators;
5. 3-dimensional contouring mills;
6. increased capacity forging extrusion presses.

The cost of the whole might amount to some £15,000,000. With a present probable cost saving of £1,000 per aircraft, it was evident that there was a long way to go before the ideal was achieved. Each item of plant could become justified only when the techniques for using it were proved, and the production gain realistic.

Progress on each item was being achieved; fortunately, perhaps, the best progress was being made with the least expensive items. New forging capacity could be justified only by a substantial elimination of present profiling methods. When it was achieved there was a danger that development of technique would then outstrip the rate of constructing the press, and the position on this expensive item, quoted as £3,000,000 to build, needed careful watching.

Reference had been made to the need to revise machining speeds and feeds to suit the material. A great deal of work was being done with temporary machining rigs for L.A. components and it was becoming increasingly accepted that if integral methods were to pay, the techniques of metal removal applied to spar millers must be secured for all removal of light alloy stock.

He felt, however, that the suggestion to reduce cutting speeds for steel might not be entirely right. A lighter tooth loading, appropriate cutter geometry and a higher speed should, with adequate cooling, give equivalent rate of stock removal with an improved finish. Much had yet to be done with liquid and gaseous coolants and with surface treatment of the cutter inserts.

Tooth loading was unquestionably reduced if the chip was segregated from the stock at a temperature which plasticised the chip. Development should be in the direction of cooling and preserving the cutter teeth, and high cutting speeds accepted.

To illustrate the point Mr. Hollis showed a graph (see above) covering a range of aircraft steels and Nimonic 90, indicating the horse power needed at different speeds to re-

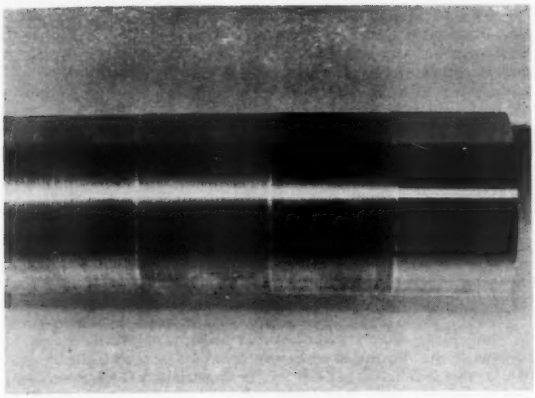


Fig. (a)

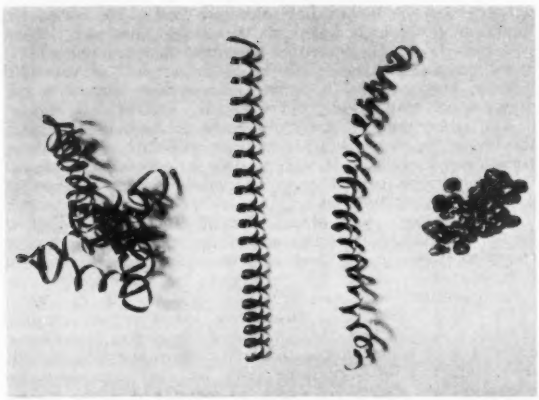


Fig. (b)

("Machinery" photographs, published by courtesy of The Distillers Co., Epsom.)

move a cubic inch of material. Generally speeds above 350 ft. per minute required less horse power than below, and the bend in some curves around this figure was marked. Much higher speeds did not involve any increase of power whatever.

The finishes achieved showed a marked improvement as speeds were increased and the chips, tough and springy at low speeds became plastic and eventually formed short, easily disposable swarf at high speeds. (See Figs. (a) and (b).)

The Paper read by Mr. Keen had ably summarised work undertaken by several aircraft firms; it was excellent to see such a spirit of collaboration exhibited. The pooling of technical information of a wide nature did exist in the aircraft industry and was being developed to a scale that might shock other branches of commerce, yet it was in this case that the strength of thought and development behind integral construction could be demonstrated, and the demand it involved be gauged.

Mr. Richards, replying to Mr. Legg's question, whether there was any hope of using lower pressures for the forgings, said that the figure which he had quoted of 20 tons/sq. in., was a generalisation, and generalisation was always dangerous. There was hope that in due course that figure might be reduced, possibly to 12-14 tons/sq. in., and work was going on in that direction. He would not like to say how long it would be before such a reduction could be made, but it should be of that order with the high strength materials and the form which was required. In that connection he showed a forging which had been made experimentally, and which he thought would be of interest. It was a forging which typified what forgers regarded as a difficult form. The interesting point was that it was free from draft. He did not want to be misunderstood on this point; it was experimental, and it would be a long time before they were able to make something of a size in which the Conference was interested. It was, however, at least a beginning, and he showed it as an example of the way in which things were going. He did not think that it mattered in which alloy it was made, and that was not the problem in the type of work in question; but it was an example of what was going on in an effort to produce something better than could be produced yesterday.

To the second question, whether the copper-bearing alloys were better than the zinc series, he did not know whether it was possible to give a direct answer, because it largely depended on what it was desired to do with them. Speaking very generally, the magnesium-zinc series offered the highest strength, but that was not necessarily true of every form, and for sheet materials the copper-bearing alloys were almost universally used, both in this country and the U.S.A.

The question of the large slab—and the slabs which were under discussion were very large—was something on which there was only limited information, and such problems as stress corrosion, stress cracking, the short transverse properties as compared with the transverse and longitudinal, and so on, were receiving active investigation, but it was difficult at the present stage to say that one alloy was better than another. He did not know whether they would be able to say in a general way that one would replace another. He thought that it would not be possible to generalise in that way, and that in fact for certain forms one material would be better, while for others another material would be preferable. It seemed to him that a rolled slab would be the answer if a slab was required, but what alloy should be used depended a good deal on the dimensions of the slab. If it was relatively thin, he thought that the copper-bearing alloys would be useful, but if it was thick there might be problems involved which had not yet been solved, as at the present stage it was not possible to offer the same strength properties throughout the section.

Mr. Menzies, replying to Mr. Hollis, said he thought there had been some misunderstanding of what was said in the Paper on the subject of cutting speeds. For the spar boom a 75/85 ton steel was used, and the point was made that when profiling was required high cutting speeds could not be attained. In Table 2, Operation 1, there was a speed of 68 r.p.m., with a 12 in. carbide-tipped cutter and a feed of 6 in./min. That was quite a reasonable speed, because the operation allowed it. In Operation 18, on the same 75/85 ton steel, there was a speed of 80 r.p.m. with carbide-tipped cutters and a feed of 6 in./min., which he thought was very fast speed. They had tackled the job with every one of the operations being done at high speed, but had found that this was not possible with the profiling machines available. They brought in a number of firms—two British, one Swedish, one German. After extensive and expensive research, the only two operations which proved successful with high speeds and carbide-tipped cutters were Operations 1 and 18.

They would be very pleased if someone would show them how to get high cutting speeds on 75/85 ton material from profiling machines. For climb milling, the type of machine available with hydraulic feed was the Cincinnati and the Cincinnati Company were consulted and said that their machines were not suitable. He would like to repeat that they would be very pleased if somebody would tell them how to cut this 75/85 ton steel at high speeds, though they had managed to do it in two operations.

Mr. W. E. Goff *(Editor, "Aircraft Production")* said that Mr. Richards had emphasised the difficulty of forging thin sections. It would be interesting if he would give his views on the relative practicability of producing thin surfaces with integral stiffening ribs by close forging or, on

the other hand, by hogging them out of large slabs, which had been suitably worked on in advance. Mr. Goff believed that Lockheed (U.S.A.) had had a considerable programme on this matter five or six years ago and had produced panels of fair size with quite thin stiffening ribs using an 18,000-ton press. From a study of the published results it seemed that all that they had proved was that it was almost impossible to get what they wanted, and he believed that they were still hogging out of the slab in the U.S.A.

Did Mr. Richards think it would be better to press on with the investigation using thin sections and close forging, or to concentrate on the provision of suitable slabs and leave the obtaining of the final form to the machine tool manufacturers?

Mr. G. W. Richards replied that the problem from the point of view of the forger was largely governed by the pitch of the ribs. If there was, in effect, sufficient room in which to introduce tools which could be cooled and heated separately, there was a chance, though it was a long way off. The American efforts in this direction, covering close-pitched stringers, had proved the difficulties involved, as Mr. Goff had said. To produce a web on a mass of metal, something 5 or 6 in. thick, was relatively simple, but when one wanted to produce a web which was of the order shown in the specimen which he exhibited, the chief problem was that it was necessary to put into the finishing die a shape which was almost that embodied in the specimen. How was that to be done? One suggestion was to go through a series of dies but, apart from the cost, that did not work. If they could heat dies uniformly to forging temperatures the pressures would be lower, and if they could cool, at the same time, parts of those dies at will they would have a much better chance. He thought that some development must be available if they were to produce these very thin sections with rather tall ribs.

His own view was that for the type of thing required, machining from a slab seemed to be the answer, at any rate for some time to come. If the pitch of the stringers was sufficient to enable one to get tools in, it might be possible to do something in the next eighteen months, but it would certainly not be possible to make a forging of anything like the size which had been illustrated that day; for that purpose it would be necessary to have presses far bigger than anything considered even in the American press programme.

Mr. A. Vines, A.M.I.Prod.E., (*Production Manager, Fairey Aviation Co. Ltd.*) said that Mr. Richards was an expert, and it would be interesting to have his views on what was a large forging. What was the largest die which could be used with confidence, and what was the largest forging which might be considered practicable in the light of present knowledge? Personally, he had not the slightest idea, and he did not think that many people had. Numbers of people had to decide whether to use large forgings and how long it would take to get them, so that it would be interesting to know what time cycle Mr. Richards would consider practical for a large forging.

In any case, the alternative method was to use slabs or hand forgings which had to be used for prototypes, possibly even twenty. He believed there was another outlet here for the slab process which made the manufacture of good slabs essential. He would like to ask Mr. Richards how much work he did on his castings before he made a forging, because experience with large forgings was that the cross-grain elongation was low. That was also one of the problems with the slabs. A great deal of attention should be given to the kneading of castings before forging or rolling to try and get the necessary elongation, across the grain.

If it were possible to produce a really good block which could be rolled to any shape, and stretched, there would be no distortion during machining. This alone would be a tremendous step forward.

Mr. G. W. Richards, dealing with the question of what was a large forging, remarked "I only wish we knew!" It was not possible to define a large forging by the weight. Speaking very generally, a large undercarriage forging, for instance, was quite a different proposition from the sort of article represented by the sample which he had brought with him. For a job with thin sections, ribs and so on, he had said earlier that 20 tons/sq. in. was required. The existing equipment in this country limited the size of forging to something about 4 ft. long and 1 ft. wide, which was very small compared with the sizes which had been discussed. If they thought in terms of the slab which was required to produce such a part, they were referring to something which weighed about 25 times as much in the rough forged condition, and if talking in terms of a slab 15 ft. long, 4 ft. wide and 3 - 4 in. thick, they were talking in terms of very large billets which had to be cast either for rolling or for forging.

One of their problems to-day was to improve the quality of that large billet, whether for rolling or forging, so as to obtain the quality which was obtained in the normal type of forging billet, of 8 or 9 in. in diameter. There was not much information available which made it possible to compare one alloy with another, or the product of one country with that of another. It was possible to have, as he had said before, a slab which gave the full specification properties in the longitudinal direction and in the transverse direction, but which failed on the short transverse. That problem did not affect this country alone; it was well know on the other side of the Atlantic, and as yet they did not know the solution, particularly with regard to the question of elongation.

The larger the size of ingot used to produce the produce, the lower the elongation would be, particularly in the short transverse direction. It was possible by forging under certain conditions to get improved properties as compared with rolling because, with rolling, working must be in one direction once it was of any length, but with forging it could be worked in other directions and that improved the properties. In the short transverse direction the elongation was often about 1%, although 4% was possible on certain sections with certain alloys.

He could assure Mr. Vines that a tremendous amount of work had gone into the question of the effects of different types of work on a billet in improving the properties, though the production of very large slabs for the purpose under discussion was something which, as mentioned in the Paper, had been with them for only a few years. Five years ago it would not have been possible to get these things, but to-day billets were often made which weighed 2 or 3 tons. Such sizes, as he had said, had not been available four or five years ago, and even those then available were not tested in the way in which the testing was now being done. Not long ago, everybody accepted forgings on the basis of the results obtained on a test-piece forged to a certain size; they did not cut up the forgings and test them, which was the standard practice to-day.

All these problems had to be borne in mind in trying to assess the one under discussion. He thought that there was hope that they would be able to improve the quality to give improved elongation, but it would not be possible to get in the short transverse direction an elongation value of 10% in the high strength alloys, although he would expect 4-5% as a minimum. The figure could not be much above that, because in the nature of things it was not possible.

Mr. A. Vines said he would be interested to hear any comments which Mr. Menzies might have to make on the steel question.

Mr. A. W. Menzies said that they had been asking for years for a machine to cut light alloys, and it should be possible without much difficulty to adapt such a machine to cut steel. It would be necessary to alter speeds and feeds, but there should be no real difficulty about it. It was desirable to make such a machine for light alloys and then deal with the cutting of steel when the problem arose. They had already waited too long so far as the cutting of light alloys was concerned. This country was late in starting but could be satisfied if a machine for the light alloys was produced. The design of a light alloy machine would be similar to a machine for steel, though the machine for steel might be heavier.

Mr. J. F. M. Oram, A.F.R.Ae.S., M.I.A.S. *(Structures Designer, The Bristol Aeroplane Co. Ltd.)* remarked that what he had to say related to the problems with which they were faced in the design of the type of construction under discussion. They had seen many illustrations of the plain leg, but both theoretical and structural studies and tests of that sort of section had been rather disappointing. It was not as good as the conventional Zed stringer riveted to skin, for loads of the order current for large civil air liners, at any rate at the moment. He would like to hear some comments, particularly from Mr. Radcliffe, on what the reactions were of the machine tool industry, and of the engineers who were designing the plant, to producing the section he regarded as essential, namely a T-section integral with the skin together with transverse ribs. Anything which fell short of that was, in his opinion, only solving part of the problem. They were more likely to get going quickly if they faced the realities. They wanted a structure which was stiffer, stronger and lighter, and which would therefore be more economic.

With regard to their prospective problems in doing this work in steel, he agreed with what Professor Connolly had said. Steel was the material which they were thinking of for supersonic aeroplanes, but for aircraft which flew in the moderate or near-high subsonic region aluminium alloys would remain in use for a long time to come.

The collaboration which an earlier speaker had mentioned between the different firms in the aircraft industry in dealing with this problem did mean a great deal. If they tackled this problem together he thought that they would make more rapid progress and thus be able to go some way towards catching up with the Americans, who had tremendous resources and manpower, energy and drive, and who were at the moment ahead of this country. In that connection, he would like to say that his Company were most grateful to the Sir W. G. Armstrong Whitworth Aircraft Company for undertaking to help with the machining of the panel to which reference had been made.

Mr. D. F. Michell, B.Sc.(Eng.), A.F.R.Ae.S., *(Development Engineer, Northern Aluminium Co. Ltd.)* stressed the importance of a stretching operation on rolled plate following solution heat treatment. Where relatively large panels were to be machined from heat treated plate, stretching was an effective method of overcoming the distortion problem. In order to meet the demands of the aircraft industry for larger sizes of rolled plate, new heat treatment and stretching equipment would be necessary. This would involve heavy capital expenditure, which was difficult to justify commercially. Nevertheless, he was hopeful that a decision to install this plant would be made in the near future.

Mr. S. Radcliffe, B.Sc., A.M.I.Mech.E., M.I.Prod.E., *(Technical Director, Wadkin Ltd.)* said that there were two fundamental approaches on the machine tool side, one from the woodcutting side and one from the machine tool side. Everything that had been said so far that afternoon had concerned the approach from the machine tool side, rather than a consideration not of the upgrading of woodworking machines, but of the designing of machinery from the woodworking angle, which was quite a different matter. It was possible to do a great many things in light alloys for a considerably smaller sum than had been talked about in terms of skin milling and so on, but such a machine would not be at all suitable for cutting steel.

There was a class of machinery about which he hoped to speak the following day of entirely new design, but which would not in any circumstances be adapted to cutting steel. The thrusts on high-speed milling in cutting alloy were, 60 - 120 lb. and no more. With steels, and particularly with 60-80 lb. and no more. With steels, and particularly with high tensile steels, which would presumably be used, the figures were of a very much greater order and an entirely different conception of the type of tool required was necessary. With these small thrusts on high-speed spindle machines, machines of one-quarter the cost would have the same capacity for cutting light alloy as a machine which would cut both light alloy and steel.

Coming to the spar milling machine itself, the position was entirely different, and any machine designed to suit the British aircraft industry should be capable of cutting both alloy and high-tensile steel spars, but the spar milling machine was a relatively heavy machine to-day, and it did not involve great additional capital expenditure to make such a machine suitable for cutting alloy and for cutting steel spars; but on the general issue there were two distinct fields of thought, one the down-grading of the machine tool as such, and the other of designing a new machine which would be half-way between the woodworking machine and a machine tool, purely for cutting alloy. Such a machine should be much cheaper than an orthodox machine tool.

Mr. L. G. Burnard *(Chief Development Engineer, Vickers-Armstrongs Ltd., Supermarine)* remarked that they had heard a light alloy forger describing his problems in a very clear and concise manner. He, too, could speak with feeling about the distortion which occurred in machining solution-treated light alloys owing to the thermal stresses set up in quenching. He believed that the Americans were using slab which contained a certain amount of chromium, which reduced the susceptibility to this quenching stress. He would like to ask Mr. Richards to say something about the effect of the addition of small amounts of chromium on the zinc-bearing light alloys.

It seemed to him that when they obtained stretch-relieved material they were going to have a stress-free material with which to work, but how were they going to do the same thing with forgings? Did it mean that they were going to have their heavy rib forgings and so on in the heat treated condition, which must surely induce those stresses from the flanges to the webs? It would not be possible to stretch these forged sections in the same way that one could stretch flat slabs, owing to the varying cross sectional areas. Would it be possible to relieve those stresses by coining in the die after heat treatment; adopting a measure of pressure coining in the die to obtain stress-free forgings?

He had seen large forgings split right down the middle of the web through the high level of stress on the flanges. They were getting over that, as Mr. Richards knew, by different heat treatment procedures, but he wondered whether they were condemned for ever to machine from the big slabs of material, because there must be a break-even limit on the purchase of large forging dies. With 100 aircraft one would pay for one's dies from the point of view of the amount of metal saved, apart from the savings achieved in machining. He would like to know what Mr. Richards felt about the future of forging in regard to the question of integral stresses induced by quenching, as against the supply of large slabs.

He would like to mention one experience which they had had which might have some bearing on work undertaken by other firms. They had had to machine a 9 ft. $\times$ 2 ft. piece of DTD 603 material, which was afterwards heat treated to the DTD 646 condition. It was $\frac{1}{2}$in. thick to be machined for a control surface skin. It had stiffeners at intervals, chordwise, and the skin itself was machined down to 0.018 in. thick in between these. They obtained a lovely oilcan panting effect in every panel. at the first effort of machining. They thought that this was due to the effect of compression stresses on the surface from quenching after solution treatment. They obtained slabs with a 2% stretch which were then machined and again had panting. There was still residual stress in the material, which showed up because they went to such a thin section. They overcame the trouble by altering the stress distribution across the material by putting it through rolls until there was a curvature in the material of the order of $\frac{1}{4}$ in./ft. The stress in the sheet was now such that there was a neutral axis along the centre with tension stresses on one surface and compression stresses on the other.

They then put it down on a vacuum chuck with the concave side downwards and using the vacuum, pulled it flat on to the working surface. They machined as before to 0.018 in., and when they took it off the chuck, instead of having a curvature of about $\frac{1}{4}$ in./ft., they found that they had a curvature of about $\frac{1}{2}$ in./ft. This proved the point about stress distribution because the compression

stresses in the upper surface had been machined away, leaving the tension stresses on the concave side to take charge, which had the effect of increasing the curvature. This was very helpful, because when the skin was pulled down on to the structure, the panels were tighter than ever, and they had no slack panels. He could give the assurance that to alter the stress distribution was a good way of getting nice tight panels even with a thickness of the order of 0.018 in.

Mr. Richards, dealing with the question of the effect of chromium, said it would take far too long to go into it at any length, but he could say very briefly that chromium was added to make the material less susceptible to stress corrosion or stress cracking. In the form of slab, sheet and extrusion which could be stress relieved by lateral stretching, the chromium addition could be quite satisfactory and was normally used. With an article of any considerable cross-section, with the chromium addition there would be trouble with the tensile properties throughout the section unless the quenching was done in cold water, and in that case the internal stress was high, but this could be relieved by stretching. It was a perfectly straightforward procedure, and such material was as good as any other; he was not going to say that it was better. With a forging, which had a non-uniform section, it was not possible to stretch it, and there would be trouble if it were quenched in very cold water and, if it was not quenched in cold water, the figures which were desired would not be obtained. It was a question of compromise, and it was difficult to generalise, but if one had a section of 3 or 4 in., non-uniform, and quenched it in hot water to keep the internal stress to a low level, the physical properties would be comparable with those of a medium-strength alloy, which was not much good.

He did not want to get into an argument about the merits and demerits of chromium. With a forging of thin section one could put chromium in and get away with it, but if it had any mass at all and had to be heat treated, there would be difficulties in that the desired properties would not be obtained. If one could make a slab and machine it to the size required and then heat treat it, the desired properties would be obtained, he thought, without much trouble, but if it had to be heat-treated in mass form, 3 or 4 in. thick, there would certainly be difficulties. That did not answer the question completely, but it would be impossible to do so in the time available. The argument had been going on for about five years The answer could be obtained only by a process of elimination, not by waving a wand and saying: "That is the trouble." They were continually investigating new phenomena, but one fact which remained was that in the case of a non-uniform section of any thickness one would have to have, if it contained any chromium, either low figures or a high internal stress. He did not want that to be interpreted, however, as saying that chromium should not be put in a forging, because that would not be correct.

With regard to coining in the die to relieve stress, **Mr. Richards** said that in addition to stretching it was possible to compress the material and release stresses. That was a complex matter in any case, and with something of non-uniform section it was very complicated and the mechanics of it were not fully appreciated. If a slab was compressed there was evidence to indicate that a low level of stress would be obtained, similar to that obtained by stretching, but that did not apply, of course, to something 16 ft. long, because to compress that would mean nibbling at it, there not being the plant to do it all at one time, and whether that would give the same figures he did not know. For small parts it was satisfactory. It was a method which had been used on compressor drums for engines for a considerable time, but there one was concerned with a cylinder and not a solid mass. These drums had been compressed to relieve stress when no other method was available. Work was going on on this question. If something of very simple form was to be treated in that way there was a reasonable chance of success, but the problem would not be solved to-morrow, because it was impossible to give even compression throughout the section.

Referring to Mr. Burnard's question on internal stresses induced by quenching, Mr Richards said that if it was a forging as big as a large desk one could have it as a slab and not as anything else, because there was not the plant available to make it.

Mr. Burnard asked what would happen with a 50,000-ton press?

Mr. Richards replied that if such a press was available, and he thought that it would be, a forging of such a size could then be made. It would not be true to say that the forging would have a high level of internal stress, because if properly treated it need not have a high level of internal stress. He could give the assurance that that was possible and was done with hundreds of forgings that were used in the aircraft industry today. There was a tendency to look on some of the problems which were met with today as due to the use of high strength alloys, but that was not correct, because they had many of these troubles a long time ago. It was a little difficult to keep pace with the aircraft industry. Mention had been made earlier of the time which it took to obtain this or that, but by and large those who were doing the buying on behalf of the aircraft industry went to the forger or roller and said that they wanted such-and-such a thing the following week or the following month, and there was not a long delay, although it was probably something bigger than the forger or roller had ever made before. Where the step to be taken was a very big one—and sometimes until they took it they did not realise quite how big it was—something might go wrong and a series of investigations might be necessary to try to develop a process which was reasonably foolproof. There were a few tips which one picked up as one went along, and a meeting such as the present Conference was a good opportunity to pass them on.

That was not the whole story; there were many other complications, but not all those complications were new ones; they had been experienced before in one form or another. It was simply that the magnitude had increased and that they were handling things in a different way and expecting more from them. The problems would be overcome. He expected that they would get the press which they wanted, although he did not know when. The Americans argued for at least seven years before they got a press, and they had not got it yet.

Mr. Vines said that they made hydraulic cylinders and had had a good deal of trouble with cracked forgings, but a forging had now been produced for them which was so beautiful that it was felt worthwhile to wrap it up in tissue paper, and that had solved a problem which had worried them for a long time.

This showed what the forgers could do when they tried.

Mr. Richards thanked Mr. Vines for his remarks, which would, he said, serve to illustrate another point. They made thousands of forgings for hydraulic cylinders for a large number of customers and had made them as ordinary forgings. If the surface of a forging in light alloy was looked at closely with a magnifying glass of × 2, one would see certain surface defects and take steps to get rid of them, but if looked at under a magnification of × 50 one would have the shock of one's life. If it were steel one would machine it and not worry about it, but light alloy had to be subjected to that examination. He did not complain, because that was what ought to be done. The case which Mr. Vines mentioned was an illustration of a mechanical trouble which occurred and which they did not see on the forged surface of the piece, even after heat treatment. It was a fold, turned in, and was revealed after final anodising of the machined component. Subsequently it was possible to trace exactly where it was formed during forging.

The view they took was that if these things were going to be used on aircraft, they would obviously be subjected to a surface examination and inspection similar to those given to other parts, and it was not much use sending something to users which had to be polished and examined;

if that standard was to be met, the forger must satisfy himself that the job was right. That meant that instead of it being a normal forging, it was now something which was literally a finished part so far as the exterior surface was concerned, and it had therefore to be wrapped in cotton wool. On such jobs where the surface was used there was no real alternative; it was the logical and sensible thing to do. A few years ago forgers would have said that they were not polishers, because polishing was involved in this case, but if they were to supply products to the standard demanded by the aircraft industry, which was a reasonable one, it was not a forging in the old sense, but a special job. It was worth making a special job of it, and it eliminated the trouble which had occurred earlier.

Mr. R. D. Edwards, A.M.I.Mech.E., (*Production Development Engineer, Vickers-Armstrongs Ltd., Weybridge*), suggested that, interesting though the subject was, the Conference was placing too much emphasis on forging and not enough on machining, because, in view of the size of panels required, existing 12,000 ton presses and even the proposed 50,000 ton press mentioned by Mr. Richards would be inadequate. A press of about 300,000 tons would be needed for panels of the size required. In any case he did not think that a forged panel would be economical, because, as Mr. Woodward-Nutt had said, orders for aircraft were likely to become smaller and the cost of dies would therefore be prohibitive. Also, it appeared that the Americans were not altogether successful with their experimental forged stiffened panels, having trouble with "suck-in" on the ribs.

He was surprised that no mention had been made of extrusions as raw materials for skin panels. He was very interested in developments of this process, but could not see anything coming from that source at the moment.

On the subject of stretch-forming of the skins, which had been mentioned by Mr. Keen and also by Professor Connolly, he would point out that they were stretching narrow panels. It was not possible to put any permanent form into a panel by stretching except by elongating it in the direction of stretch, and it was not possible to do that without introducing a waist in it, decreasing in width progressively towards the centre. On a narrow skin that might perhaps not be noticeable, but on wider skins, such as were required for making integral tanks for medium or heavy aircraft, it would be a serious problem because sealing would be affected.

Slabs for machined integral skins needed to be stretched. He thought Mr. Hollis could forget about a stretching machine and the necessary rolling plant to cater for a slab width of 10 ft., but if he would provide a machine for stretching slabs as wide as could be rolled at the moment, and as thick as the industry required, it would be a great step forward.

No mention had so far been made of milling panels in the flat, and forming subsequently by shot peening. The design must lend itself, of course, to that method of forming. Shot peening only lent itself to panels which were stiff in the direction in which they were required to be flat, and weak in the direction in which curvature was required. If designers could be persuaded to design skins of that nature, he was sure that they could be formed by shot peening. At Vickers-Armstrongs experiments had been carried out with excellent results using that method, which would enable them to machine such skins flat.

Machining in the flat offered many advantages over machining to contour. All panels, if machined flat, could be held on flat vacuum chucks; whereas for contour milling, contoured vacuum chucks would be required for every single panel, left hand and right hand. That was a considerable item of equipment when dealing with medium size and large aircraft. An enormous amount of time would be saved by being able to hold the slabs for every panel on a flat vacuum chuck, which could almost be built into the machine, rather than having to set up a different contoured chuck for every panel to be machined.

He thought there was bound to be more distortion when machining a slab to contour, and there would be little chance of correcting it. With a flat slab it was possible to reduce distortion progressively by machining first one side of the slab and then the other, but when machining to contour, he did not see how this procedure was possible.

Another important point was that if one machined a panel in the flat and formed it to contour afterwards, the thinnest possible section could be used, thereby having to machine away the least amount of metal. Also, the thinner the slab, the better its mechanical properties, because more work had been done on it during manufacture.

He did not know why shot peening as a means of contouring flat panels had not been considered by other firms. There was, after all, a precedent in the U.S.A., where the largest integral panel flying at the moment was the 32 ft. × 4 ft. panel on the Super-Constellation. That was produced by milling in the flat, floor to floor time being 11 hours, and subsequently forming to contour by shot peening. By suitably distributing the shot and by varying the peening pressure, the contour could be produced with sufficient accuracy at one pass. He thought that it was a method which should be investigated.

He would like to ask Mr. Keen and Mr. Menzies whether they had considered machining in the flat and contouring by the shot peening process before they designed their contouring machine.

Mr. Keen, replying to Mr. Edwards, said that the first point which Mr. Edwards raised concerned extrusions. He had indicated earlier that it was difficult in a Paper to a Conference to put down everything that one knew on the subject, but it would be recalled that he said that they had considered using extrusions as the third method of making the Meteor tailplane, and as a result of their experience in Phase 2 they decided that it would be perfectly possible to do that. The difficulty, however, had been to persuade anybody to stretch a long enough piece of extrusion out to anything like the shape which could be stretch-formed. He associated himself with the remarks made by Mr. Edwards about the possibilities of extrusion, which had very great attractions.

Another speaker had referred to large amounts of scrap. There was no doubt about that, and that led to a further point which had to be raised, concerning the use of a flat-machining process in making economies in the size of the slab. If reference was made to Fig. 4 of the Paper, it would be seen that that problem was dealt with quite fully, because the top example was equivalent to the first method of making the first tailplane. One started off with a slab big enough to contain the chordwise curvature and the spanwise dihedral, and out of a slab of 667 lb. the estimate was that one took off 646 lb., ending up with something which weighed about 23 lb. That was obviously very uneconomic indeed.

The next intermediate stage was to obtain a kinked billet which would include the dihedral, but deep enough to contain the chordwise curvature, and immediately the weight of the billet was more than halved; next came the method which Mr. Edwards advocated, which was to do the whole thing in the flat, and then the weight of the billet came down to 256 lb. The final stage was to use an extrusion, in which the actual extrusion would be a mere 85 lb., and that would include an allowance for an even area for stretching, which Professor Connolly said was not necessary, because they could have stretched a tapered one, and then the figure would be 62 lb., still with an allowance on the outside for getting a nice surface finish. He, therefore, concurred heartily with Mr. Edwards' remarks and thought it most important to consider the ways of manufacture in relation to the question of the billet.

So far as shot peening was concerned, they had heard of the experiments in that direction to which Mr. Edwards had referred and were interested in them, but he had no information himself and that had not been one of the methods which they explored.

Mr. Edwards had asked whether they had considered machining in the flat before putting forward their proposed skin milling machine. It was all a question of structural loading coefficients. In Mr. Legg's Paper (Ref. 1), the structural arguments were developed. The Meteor tailplane,

as mentioned in the present Paper, was a very lightly-loaded piece of structure, and in design studies for supersonic aircraft, not quite at the advanced stage where steel was necessary; with M = 1 - 1.5 it would be found that light alloy sheets were needed of about ½ in. thickness. Incidentally, this had also been illustrated by Mr. Woodward-Nutt as the thick integral box spar for supersonic aircraft light alloy wings. He would like to ask Mr. Edwards whether shot peening had any future in trying to contour from the flat to a curve with light alloy sheets ½ in. thick. He would not have thought so.

Mr. Edwards replied that peening was suitable only for skins stiffened in one direction, which was the type of panel which would be required on the next aircraft which was not going to be supersonic. The medium to heavy aircraft he was considering would not be supersonic for some time.

Mr. Keen said that the skin miller was intended for aeroplanes with very high flange structural loadings, and from their experience in trying to form thick skins, it was concluded that in order to get a desirable skin surface there was need for a skin miller for the final cut.

Professor Connolly did not accept the suggestion that "necking" was inevitable in a stretch-formed panel. Even in the tapered panel, he said, the difference in elongation along the panel, although it had double curvature and was heavily tapered, was not more than about 0.5% in an experiment which had been done to see what the problems were. It was possible to control panels on a stretch-forming machine by exercising care before pulling them, and so not get necking to any extent which could cause anxiety. Of course, there was some "end effect" at the jaws but this could be allowed for.

Mr. Hollis explained that when he referred to a 10 ft. wide rolling mill, he meant 10 ft between the columns. Width of sheet or slab might require this but the section to be stretched could not, obviously, exceed the capacity of a given stretch press.

Wider slabs could only be achieved at the expense of thickness.

Mr. Keen refuted the suggestion that the necking referred to by Mr. Edwards was progressive from the centre. There had been a reduction in width which could be measured on the Meteor tailplane, but it had been overcome, because there was a cut-away front spar, the web was attached at a separate angle, and adjustments could be made for that. He thought that the actual variation in the width was an end effect, so that necking, if it took place, would occur very near the end, and, as there had to be an allowance to permit gripping the panel, the variation need not cause any anxiety. In their experience, however, it was correct to say that there was a slight reduction in width. which had been allowed for.

Mr. W. Horton, A.M.I.Mech.E., Grad.I.Prod.E., (*Production Development Engineer, The Gloster Aircraft Co. Ltd.*) asked whether, after all this extensive machining had been carried out, in which great attention had been paid to limits, a hand finishing operation, which could not possibly be controlled to limits, was to be used to introduce some high surface finish, and whether this surface finish was going to be an important design requirement in view of the very thin skins that were being proposed.

Mr. Menzies said that surface finish was a subject which was much to the fore, but they had not referred to it in their Paper, perhaps intentionally. They did hand finish the skins; they thought that surface finish was important for two or three reasons, and obtained a good finish by hand. With regard to steel spar booms and undercarriage beams, they did a certain amount of finishing. It was his personal opinion, that a terrific amount of work was put in on surface finish because it was the fashion. He did not want to be misunderstood; he did not take the view that rough machining marks should be left in—far from it. He thought that good machining was essential. In going through the shop, however, one found that everyone was calling out for parts to be polished and looked at, and someone would mention micro-inches, without knowing what they were; if one asked what was meant by 15 micro-inches, one got all sorts of replies.

The point which he wished to make was that the polishing which was put on flat surfaces was not so essential as polishing or cleaning in change of section or in radii, and this was fundamentally machining, in his opinion; it should not be polishing. The cutters should be ground better and even lapped. One might find score marks along every radius on a part, but it would go through because it looked nice. Surface finish was essential, but essential in the right place. They did barrel surface finishing and had tried vapour blasting. Skins should have a very good surface finish, but he was talking about the ordinary machined parts in the shop, and the booms, and there it was necessary to make sure that the surface finish was in the right place. Mr. Keen, as a designer, might like to comment on that.

Mr. Keen said that the effect on fatigue was important, but he agreed with all that Mr. Menzies had said. The question of stress raisers was not very intimately connected with the finish on large flat surfaces, particularly as the machining was more or less in the direction of the load, but a good deal more attention should be paid to radii and the finish of holes and various other stress raisers which designers found it impossible to eliminate. If some of the effort exerted in the micro-inch field were transferred to these areas it would be of much more value, and incidentally he knew that the engine manufacturers paid a great deal more attention to this aspect of surface finish.

Mr. J. Hall, (*Development Engineer, Blackburn and General Aircraft Ltd.*), said that distortion in the high-grade material had been emphasised, and it had been stated that stretching the materials reduced the distortion a great deal, whilst not eliminating it altogether. The stretching equipment in this country at the present time was sufficient for a section of 60 sq. in., (say, 20 in. wide and 3 in. deep). They had heard what was "round the corner", but it might be a very broad corner. They were more concerned with being able to get slabs of much wider dimensions than 20 in. for the integral construction of main skins now, and they knew that the suppliers of that material could not get improved stretching equipment for two years at least.

Reference had been made to stress relieving by solution treating at an elevated temperature. Until stretching equipment was available which was capable of taking wider widths, he asked whether this elevated temperature method could also be used to relieve the internal stresses on roller levelled material and, when the stretching equipment was available, could not the two "relievers" be additive?

Mr. Richards replied that the simple answer was: "Yes". It was possible to produce slabs of a composition which made it possible to quench at a high temperature and keep the stress down to a reasonable level. He would not like to say that there was no limit to the size at all, because the question of equipment came into it, but broadly the answer was: "Yes"

On the question of whether the two stress-relieving treatments could be additive, he thought that material which was hot-water quenched and then stretched would have a lower level of internal stress in it than one which had not been stretched.

Mr. Hall said he had asked the question deliberately, because he had been told by another supplier that, if that was done, the material would be very susceptible to stress corrosion, and fatigue would come into it.

Mr. P. S. W. Swaby, B.Sc., (*Assistant Development Manager, British Aluminium Co. Ltd.*), asked whether Mr. Richards could suggest any theoretical reason for the behaviour of the anodised forging on quenching, which he found very interesting.

Mr. Richards said it was thought that the explanation was that the anodised film did not permit the formation of the normal steam film around the part during quenching. That was the only explanation which had been found so far which seemed to fit the facts, but whether it was a complete answer he did not know.

The Conference then adjourned at 7 p.m., until 9.30 a.m. the following day.

REPORT OF THE ANNUAL GENERAL MEETING

Thursday, 27th January, 1955.

THE thirty-third Annual General Meeting of the Institution was held on Thursday, 27th January, 1955, at 4 p.m. at the Headquarters of the Institution, 10, Chesterfield Street, London, W.1. The President, Sir Walter Puckey, was in the Chair.

Election of Members to Council

The Report on the Election of Members to Council was received on the motion of Mr. R. E. Mills, seconded by Mr. B. G. L. Jackman.

Annual Report of Council

Mr. G. R. Pryor, the Chairman of Council, in moving the adoption of the Annual Report, said that the New Building Appeal Fund now totalled £16,500, and donations were still being received. The current year's finances were going very much according to plan and if all went well there would be a surplus of income over expenditure at the end of the year. It was anticipated that the overdraft on the current account would not exceed £4,000.

Membership continued to increase, and it seemed that the tightening of the membership regulations had not noticeably stopped the flow of applications to join the Institution.

Mr. B. W. Gould seconded the motion, and the Annual Report was adopted.

Statement of Income and Expenditure, Balance Sheet and Auditors' Report

On the motion of Mr. G. R. Pryor, seconded by Mr. F. T. Nurrish, M.B.E., the accounts were adopted unanimously.

Election of Auditors, 1954/55

On the motion of Mr. S. A. J. Parsons, seconded by Mr. A. G. Clark, Messrs Gibson Appleby & Co., Chartered Accountants, were re-elected Auditors to the Institution and thanked for their services.

Election of Solicitors, 1954/55

On the motion of Mr. E. Percy Edwards, seconded by Mr. M. C. Timbury, Messrs. Syrett & Sons were re-elected Solicitors to the Institution and thanked for their services.

Votes of Thanks

The President said that he had the extremely comprehensive task of thanking Mr. Harold Burke, Mr. G. R. Pryor and all Officers of the Institution, but he did not feel that a "composite" vote of thanks was sufficiently personal.

This Annual General Meeting dealt with the year during which Mr. Burke was Chairman of Council. There was a great deal for which Council had to thank Mr. Burke. He had put in a lot of work which was of the utmost value, and had indeed done a fine job for the Institution. Quite apart from the developments which had taken place under Mr. Burke's vigorous leadership, he had proved himself to be a most competent Chairman, who had conducted the business of the Council in a most admirable manner.

It was also right to speak in similar vein of the present Chairman of Council, Mr. Pryor. One of the most important things which any man could do in life was to make sure that his successor followed in the tradition he had tried to set up. In Mr. Pryor, it would be unanimously agreed, Mr. Burke had a successor who was not only following, but standing well ahead of, the tradition. He had a delightful personality, he was a man who got things done in an efficient manner and a man who, although he had not always been in the best of health, had given the Institution of his best. The Council were proud to have him as Chairman.

It was with great pleasure that the President moved a hearty vote of thanks to Mr. Burke, Mr. Pryor, and all Officers of the Institution. The vote of thanks was carried by acclamation.

Mr. Pryor, in response, thanked the President for his kind remarks and members of Council for the way in which they had received them. Unfortunately Mr. Burke was indisposed, otherwise he would have been present. He would be delighted when the sentiments which had been expressed were conveyed to him.

With regard to the permanent staff, continued Mr. Pryor, the Institution was indeed very fortunate. Although their services were acknowledged in the Annual Report, he would like to take this opportunity of assuring them how much the Council and members appreciated what they were doing, and the interest as well as the loyalty they showed. He had much pleasure in proposing a vote of thanks to the permanent staff of the Institution. The vote of thanks was carried by acclamation.

Mr. H. G. Gregory proposed a hearty vote of thanks, which was carried by acclamation, to Sir Walter Puckey, not only for the inspiring example which he set them all as President, but for the manner in which he had conducted this Annual General Meeting. The Annual General Meeting then terminated.

REPORT OF THE MEETING OF COUNCIL

Thursday, 27th January, 1955.

THE third Council Meeting of the 1954/55 Session was held at 10 Chesterfield Street, London, W.1., on 27th January, 1955. The meeting, which was presided over by the Chairman of Council, Mr. G. R. Pryor, was attended by 29 members, and the following were present by invitation: Mr. B. W. Gould, Hon. Secretary, Midland Region; Mr. D. G. Swinfield, Hon. Secretary, North Midland Region; and Mr. W. S. Silberbach, Chairman, Birmingham, Graduate Section.

Finance

It was reported by the Finance and General Purposes Committee that the position as shown by the Income and Expenditure Account on 31st December was healthy, the budget being maintained both as to Income and Expenditure.

National Conference, 1955

It was reported that arrangements for the National Conference, to be held at Margate from 16th/19th June, 1955, were well in hand. A Committee had been elected to deal with the organisation of the Conference, under the Chairmanship of Major-General K. C. Appleyard, C.B.E., and a Sub-Committee, under the Chairmanship of Mr. A. F. Kelley, was arranging the programme.

The Secretary informed the Council that a great deal of interest had been aroused by the announcement of the Institution's intention to hold a Conference dealing with the automatic factory, and he had already received a number of applications to attend from individuals and bodies outside the Institution.

It was hoped that the full details of the programme would be ready for circulation to members by the end of February.

Aircraft Production Conference

In the absence of Mr. F. T. West, M.B.E., Chairman of the Southern Section, the Secretary reported that the third Aircraft Production Conference had been extremely successful. There had been a record attendance, in spite of the very unfavourable weather, and it was noticeable that every major aircraft company in the U.K. was represented at senior executive level. The Southern Section had rendered good service to the Institution by establishing these Conferences.

Cornwall Section Conference

The Secretary reported that the Cornwall Section were arranging a two-day Conference, to be held on 13th and 14th April, 1955, dealing with the use of compressed air as an aid to improved productivity. This was a serious attempt to promote interest in the Institution in the far West and the programme looked very attractive.

Specialist Divisions

Arising from the Research Committee's proposal that the Institution should establish Specialist Divisions, the Finance and General Purposes Committee had appointed a special sub-committee to consider this question.

The Journal

It was reported by the Editorial Committee that the editorial content of the Journal was steadily increasing. A new series of leading articles on "Education and Research for Production" had been launched, and notable contributions had already been published from Sir Ben Lockspeiser and Professor H. Wright Baker.

Notice of termination of contract had been served on the Institution's Advertising Agents, so that a new contract might be negotiated.

Institution Papers

The 1954 Viscount Nuffield Paper was presented at the Royal Institution London, on 9th December, 1954, when Major-General W. A. Lord, C.B., C.B.E., Director of Mechanical Engineering at the War Office, spoke on "The Work of the Corps of the Royal Electrical and Mechanical Engineers and the Application of Modern Management and Production Technique". A full report of the meeting appeared in the February issue of the Journal.

The 1954 George Bray Memorial Lecture. The Institution had invited Mr. Robert Douglas, O.B.E., Chairman and Managing Director of Dobson & Barlow Ltd., to present this Paper at a Regional

Meeting to be held in Manchester on 18th April, 1955. The proposed subject was "Engineering and Production Aspects of Synthetic Fibre Manufacture".

Summer School

It was reported by the Education Committee that the 1955 Summer School would be held at Ashorne Hill, Leamington Spa, from 24th/28th August. The theme would deal with anticipated developments in industry and in education in relation to future requirements, particularly in management; the proceedings of the School would endeavour to show what changes in technique are envisaged, what are the future opportunities in industry, and how education can assist in meeting the new requirements.

Research

The following reports were made on behalf of the Sub-Committee of the Research Committee:

Materials Handling. The Sub-Committee were now engaged on detailed work in connection with the proposal that a Materials Handling Division be established within the Institution, and in collecting Case Studies, with another publication in mind.

Materials Utilisation.. The Sub-Committee had selected 62 Case Studies for inclusion in their Report. It was hoped that the final draft of the Report would be available by the Spring.

Production Control. The final draft of the Sub-Committee's Report was now completed and would shortly be considered by the Joint Committee.

Sources of Information. Lists of potential sources of information had been compiled, and an introductory article written, for publication in the Journal prior to the publication of the Directory of Sources of Information.

The Research Committee had appointed Mr. R. N. Marland to represent the Institution on a sub-committee on Casting Design set up by the Institute of British Foundrymen.

Standards

It was reported that Mr. R. E. Mills had been elected Chairman, and Mr. W. E. Wright, Vice-Chairman of the Committee for 1954/55. The Committee continued to comment on draft specifications and to appoint Institution representatives to B.S.I. Technical Committees, at the request of B.S.I.

Hazleton Memorial Library

It was reported that the use of the Library continued to increase, and that more members were calling personally, to make use of the increased facilities now at their disposal. The Library catalogue was now in the proof stage and would be available to members soon.

Miss M. L. South, B.A., F.L.A., took up the position of Librarian at the beginning of January, replacing Mrs. P. L. Steane, B.A.

Production Exhibition 1956

It was agreed that the Institution should accept the invitation of Andry Montgomery Limited, to sponsor the second Production Exhibition, to be held in 1956.

The Secretary informed the Council that as a result of the 1954 Production Exhibition, Andry Montgomery, Ltd. had been able to meet all their expenses and to place a deposit on the venue for the 1956 Exhibition. In addition, they had presented the Institution with a cheque for one hundred guineas, which it was suggested should be used for some educational purpose. It was hoped that arising from subsequent Exhibitions a capital sum would be built up which, when invested, would provide sufficient interest to endow a scholarship or a similar project.

Attendance of Section Hon. Secretaries at Council Meetings

On the motion of Mr. J. E. Hill, seconded by Mr. F. T. Nurrish, M.B.E., the Council agreed that two Section Hon. Secretaries in rotation should be invited to attend each Council meeting.

Elections and Transfers

The Council approved a number of transfers and elections to membership, particulars of which appear on page 192 of this issue of the Journal.

Local Section Reports

The Council received a number of Local Section Reports, extracts from which appear on pages 193 to 196 of this Journal.

Honours

The Council warmly congratulated the following members upon the Honours they had recently received:

Mr. H. Spurrier	Knight Bachelor
Mr. F. W. Halliwell	C.B.E.
Mr. B. A. Williams	C.B.E.
Mr. H. W. Hobbs	C.B.E.

Obituary

The Council recorded with deep regret the death of Sir Ernest Lemon, O.B.E. President of the Institution from 1942/44, and of Mr. A. H. Barber, A.M.I.Prod.E., and Mr. A. Lumb, A.M.I.Prod.E.

"Broadening of the Base"

The Council devoted the rest of the meeting to a detailed discussion on membership policy. Mr. B. G. L. Jackman, Chairman of the Sub-Committee appointed to consider certain aspects of the subject, reported on the findings of the Committee to date, and on the views of Sections.

At the conclusion of the discussion, Mr. Jackman thanked the Council and said that their observations would be very valuable to his sub-committee.

ELECTION OF MEMBERS

Thursday 27th January, 1955.

The following were elected to membership by Council:

ADELAIDE SECTION

AS ASSOCIATE MEMBER
H. Lander.

BIRMINGHAM SECTION

AS MEMBERS
B. E. Cook, G. W. Harriman, A. J. Worster.
AS ASSOCIATE MEMBERS
G. W. Stokes, B. J. Webster.
AS GRADUATES
R. Armstrong, H. G. Deboo.
AS STUDENTS
A. E. Bettinson, R. T. Hill, G. B. Lee, E. J. Wellavize.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
J. B. Lloyd
FROM GRADUATES TO ASSOCIATE MEMBERS
D. Clayton, L. Martin, L. R. Mumford, D. L. Taylor.
FROM STUDENTS TO GRADUATES
R. D. Flint, G. S. Morrish, R. B. Myring, M. J. Strevens, D. J. White.

BOMBAY SECTION

AS STUDENTS
D. M. Bir, M. S. Paul, K. V. Ramaseshan.

CALCUTTA SECTION

AS ASSOCIATE MEMBER
D. S. Krishnamurti.
AS GRADUATE
V. M. Bhandarkar.
AS STUDENTS
G. S. Padan, D. K. Pal.

CANADIAN SECTION

AS MEMBER
L. Gruber.
TRANSFER
FROM STUDENT TO GRADUATE
A. M. Hand.

CORNWALL SECTION

AS STUDENT
A. S. M. Brown.

COVENTRY SECTION

AS MEMBER
A. Jennings.
AS GRADUATES
H. Bridges, W. S. Haley, S. J. Eaton, D. E. John.
AS STUDENTS
M. C. Lewins, J. M. Nunn.
TRANSFERS
FROM ASSOCIATE MEMBERS TO MEMBERS
J. Harris, S. W. D. Lockwood.
FROM GRADUATE TO ASSOCIATE MEMBER
S. Basketts.
FROM STUDENT TO GRADUATE
W. G. Harris.

DERBY SECTION

AS STUDENTS
J. H. Cox, C. V. Smith.

GLASGOW SECTION

AS MEMBER
N. J. D. K. Bruce-Kingsmill.
AS GRADUATE
G. A. Paisley.
AS STUDENT
D. McWhinnie.
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
J. C. Campbell.

LEICESTER SECTION

AS ASSOCIATE MEMBER
S. R. Killey.
AS GRADUATES
M. Ahmad, J. C. Khurana.
AS STUDENT
N. Walker.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
K. G. Adcock.
FROM GRADUATE TO ASSOCIATE MEMBER
M. J. Vivian.
FROM STUDENTS TO GRADUATES
R. R. B. Bruce, S. M. Husain.

LIVERPOOL SECTION

AS STUDENT
O. Dakes.

LONDON SECTION

AS MEMBER
H. E. Cooper.
AS ASSOCIATE MEMBERS
L. A. Bailey, H. R. W. Deacon, V. H. A. Diederichs, T. J. Mackrill, E. W. Myers, I. H. Nickols.
AS GRADUATES
P. H. Banks, E. W. Batchelor.
AS STUDENTS
M. R. Hulbert, A. H. Mills, B. J. Taylor.
TRANSFERS
FROM ASSOCIATE MEMBERS TO MEMBERS
H. E. J. Butler, A. D. Granger, H. P. Jost, K. A. W. Mollart.
FROM GRADUATES TO ASSOCIATE MEMBERS
R. L. Jopson, A. P. Lambert, A. F. Masters, S. J. Wylde.
FROM STUDENTS TO GRADUATES
S. R. Clayton, K. G. Catlin, P. Kerrin, S. A. Richardson.

LUTON SECTION

AS STUDENT
C. Halton.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
H. J. Hudson.
FROM GRADUATES TO ASSOCIATE MEMBERS
E. H. Goldsmith, R. Moggridge, C. O. Webb, D. F. Wortham.
FROM STUDENTS TO GRADUATES
P. W. Bone, M. J. Hemmett, R. W. Hogarth.

MANCHESTER SECTION

AS GRADUATE
J. Chapman.
AS STUDENT
D. Baxter.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
F. Newitt.

MELBOURNE SECTION

NEW AFFILIATED FIRMS	NEW AFFILIATED REPRESENTATIVES:
John Danks & Son Pty. Ltd. ...	F. M. Danks.
	S. E. Miller.
H. V. McKay Massey Harris Pty. Ltd.	D. H. Ferguson.
	A. Ustick.
Wickman (Aust.) Pty. Ltd. ...	G. W. Hunt.
	B. E. Round.

NORTH EASTERN SECTION

AS MEMBER
W. A. Peart.
AS ASSOCIATE MEMBER
R. Gabriel.
AS GRADUATE
J. D. Thomson.
AS STUDENT
S. N. Bansal.

NORTHERN IRELAND SECTION

TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
T. S. G. Kee.

NORWICH SECTION

AS ASSOCIATE MEMBER
J. M. Platt.

PRESTON SECTION

AS GRADUATES
M. Innis, C. D. Peters.
AS STUDENT
M. B. Bolt.
TRANSFER
FROM STUDENT TO GRADUATE
J. Shorrock.

READING SECTION

AS ASSOCIATE MEMBERS
E. J. Pearson, G. Rees.
AS STUDENT
M. T. G. Hughes.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
P. R. Browse.

ROCHESTER SECTION

AS STUDENT
G. E. Lawson.

SHEFFIELD SECTION

AS ASSOCIATE MEMBER
S. Davis.
AS GRADUATE
R. Bradshaw.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
C. Ellis.
FROM GRADUATE TO ASSOCIATE MEMBER
J. H. Shore.
FROM STUDENT TO ASSOCIATE MEMBER
R. W. McEvoy.

SOUTHERN SECTION

AS STUDENT
T. L. Ford.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
A. Black.
FROM GRADUATES TO ASSOCIATE MEMBERS
L. A. Daish, D. G. Finikin.

SOUTH ESSEX SECTION

AS GRADUATE
J. Handley.

SOUTH WALES SECTION

AS ASSOCIATE MEMBER
A. M. G. Rodway.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
J. Alldrick.
FROM STUDENT TO GRADUATE
G. E. R. Mobley.

SYDNEY SECTION

AS MEMBER
J. Frail.
AS ASSOCIATE MEMBER
K. C. Gibbs.
AS STUDENTS
K. N. Rowles, J. W. Smith.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
W. L. Lober.

WESTERN SECTION

AS STUDENT
J. R. Stainer.
TRANSFERS
FROM STUDENTS TO GRADUATES
M. C. Clinch, E. G. J. Newman.

WEST WALES SECTION

TRANSFER
FROM STUDENT TO GRADUATE
C. G. Parry.

WOLVERHAMPTON SECTION

AS ASSOCIATE MEMBER
H. P. Warner.
AS STUDENT
A. Boyce.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
J. A. W. Styles.
FROM GRADUATES TO ASSOCIATE MEMBERS
R. J. Broomer, R. J. Sury.

WORCESTER SECTION

AS GRADUATES
D. W. Edwards, H. F. Lowe.

YORKSHIRE SECTION

AS GRADUATE
A. A. Fryer.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
C. L. Taylor.
FROM GRADUATES TO ASSOCIATE MEMBERS
A. Beaumont, D. Mallison.
FROM STUDENT TO GRADUATE
J. B. Watts.

NO SECTION

AS ASSOCIATE
H. J. Hille.
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
R. Taylor-Thomas.

EXTRACTS FROM LOCAL SECTION REPORTS

Presented to Council, 27th January, 1955.

EASTERN REGION

Eastern Counties

The Winter Session commenced in October with a combined meeting with the Colchester Engineering Society, when Mr. J. Fallows read a paper on "The Process Development of Shell Moulding". This lecture was well attended and those present enjoyed a first-class lecture, illustrated by slides, colour film and examples of work cast using the process. The November lecture in Ipswich was given by Mr. R. E. Reason, A.R.C.S., on "Surface Finish". The lecturer described some methods of measuring and comparing various surfaces and the Paper was well illustrated by slides and apparatus.

The December lecture was arranged bearing in mind the "Broadening of the Base Policy" of the Institution, and Mr. D. C. Nicholas spoke on the subject of "Plastics — Materials, Processes and Machines". The paper included reference to the applications of some of the thermoplastics manufactured at present, and described some of the machines used for the continuous production of these materials. The Paper was again well illustrated by lantern slides.

Norwich

The period under review covers the first half of the Session's programme, and it is gratifying to be able to report that there has been a distinct increase in the number of members and visitors attending the lecture meetings.

The opening meeting of the Session in October was held in Lowestoft, when a Paper was presented entitled: "Arc Welding in Engineering and Shipbuilding". This was the first occasion that a meeting of the Section had been held in Lowestoft and the results were most encouraging, so that this may well become a regular feature of future programmes.

Two lecture meetings have been held in Norwich, at which Papers were given on the subject of "Planned Maintenance" and "The Work of PERA". Both these meetings also proved most successful.

EAST AND WEST RIDINGS REGION

Doncaster

The Section lecture programme opened in October with a well attended lecture by Committee Member, Mr. T. B. Maddison, B.E.M., A.M.I.Prod.E., who gave a very interesting lecture on "Production Methods in Railway Workshops". The second lecture in November was given by Miss A. G. Shaw, M.A., M.I.Prod.E., followed by a lively discussion.

The membership of the Section continues to grow steadily.

Halifax

To open the winter programme, a Regional Meeting was arranged in October and a good number of members and visitors from the Doncaster, Halifax, Sheffield and Yorkshire Sections attended. The Paper, on "Industrial Uses of Terylene", was well presented by Mr. D. N. Marvin, of the I.C.I. Terylene Council. In November, the lecture on "The Shell Moulding Process" attracted a good number of visitors. A team of three members and three non-members representing local industries answered questions which had been invited from the members; this was a most successful meeting, and a much fuller report than usual appeared in the local press.

During the period under review, the Committee have been at work with the day-to-day business, and attendance of representatives at the Regional Committee meetings has been practically 100%.

Sheffield

The Section Committee have studied the report on "Broadening of the Base" submitted by the Education and Membership Committees. A sub-committee of four was assigned to study it in detail and have drafted a series of recommendations to be discussed by the full committee at a special meeting convened for this purpose.

The Session opened officially with the Annual Dinner in early October, when the Section was honoured by the presence of several notable personalities, including Sir Walter Puckey and Mr. W. F. S. Woodford. Sheffield was officially and ably represented by The Lord Mayor and The Master Cutler, and the Chief Speaker was Sir Charles Goodeve. Over 240 guests, covering a wide field in engineering, had a very enjoyable evening.

Yorkshire

The lecture meetings are being reasonably well supported, and it is hoped that all new members will make themselves known to the Chairman and Secretary at the first opportunity.

MIDLANDS REGION

Birmingham Graduate

The Birmingham Section Chairman, Mr. T. W. Elkington, M.I.Prod.E., is arranging to have a short descriptive notice of Graduate meetings included in the "Birmingham Post" monthly calendar.

A visit to Jury Holloware Ltd., took place in October. This event was well attended and all concerned had an interesting and enjoyable evening.

The Committee decided not to hold a lecture meeting in December. A lecture was held in January when Mr. N. Stubbs, M.B.E., B.Sc., the Editor of "Machinist", spoke on "Productivity and the Machine Tool".

Coventry

A fire at the usual venue for lectures caused a last minute change which unavoidably resulted in a number of members and visitors not gaining admittance to the November lecture, "The Design of Transfer Machines and Application to Production" by Messrs. H. W. Holbeche and F. Griffiths. However, the lecture was very well received by a capacity audience and a lively discussion followed.

The Annual Dinner and Dance was again held at the Matrix Hall, and was thoroughly enjoyable. In addition to the Lord Mayor and Lady Mayoress of Coventry, the guests included a number of well-known industrial executives.

The Committee recently accepted with the utmost regret the resignation of Mr. C. J. Swain, M.I.Prod.E., who has been a member of the Committee for a number of years, a past Hon. Secretary, and an Additional Section Representative on Council.

Coventry Graduate

The Section's October Meeting took the form of a talk, with the aid of some excellent slides, by Mr. R. C. Fenton, M.I.Prod.E., on: "Some Interesting Set-Ups on Modern Machine Tools". In arranging the November meeting the Committee endeavoured to improve attendance by making it a joint meeting with the Graduates of the Institution of Mechanical Engineers (Automobile Section), thus reducing the meetings available to both groups to one during November and avoiding a clash of dates. In order to deviate from the straight lecture, a debate was held on the subject of "Should Production Control Design?" The success of the meeting was in no small way due to the contribution from the Chair of Mr. H. Eckersley, a Member

of both Institutions. The December lecture was given by Mr. C. Cooper on "The Application of Scientific Administrative Methods to Engineering Production".

Wolverhampton

Dr. R. H. Barfield, D.Sc., M.I.E.E., presented a Paper entitled "High Frequency Heating and Induction Hardening" to an extremely well attended meeting, in November. The December lecture, "Control of Production as Applied to the Manufacturing of Small I.C. Engines", was given by D. Dudfield, B.A., A.M.I.Prod.E.

Monthly meetings of the Committee have been held and well attended. Particular attention is being given to the Joint Education and Membership Committees' request for consideration of the proposals relating to "Broadening of the Base". Messrs. W. G. Ainslie, G. A. Firkins, P. J. Shipton and H. Grisbrook have been co-opted to the Committee.

Wolverhampton Graduate

In October a most interesting Paper on "Safety in the Factory" was presented by Mr. E. W. Huddy, H.M. District Inspector of Factories, which was illustrated by a number of photographs. The attendance at this lecture was very good.

In December a lecture was given by Mr. D. J. Bridge, A.M.I.Prod.E., on "Some Aspects of Materials Handling in Industry".

During November a meeting was held at which Mr. W. F. Garnham, who visited America in 1953, with a Specialist Team of Industrial Engineers, gave his Paper on "Some Impressions of a Visit to America with a Productivity Team". This lecture was well attended and a lively discussion followed.

A works visit was made in October to the Wolverhampton Die Casting Co. Ltd. A tour of the Company's offices was carried out including the design drawing offices and inspection laboratories for completed castings. The December visit was made to the Ductile Steels Rolling Mills, Willenhall, when a party of thirty toured the stock yards, furnaces and mills.

The Graduates' Dance was held in October and was attended by over 200 members, their wives and friends.

In addition to the above educational programme of lectures and visits the Committee have held two committee meetings a month. The Conference Sub-Committee are arranging the Programme for the Fifth Graduate Conference which is being convened in Wolverhampton in March, 1955.

NORTHERN REGION

North Eastern

Following the opening of the new Session by Mr. T. McCulloch, who delivered his Chairman's address, two very well attended meetings have been held. In October, Mr. A. Woods presented a very interesting Paper on "Shell Moulding for the Production Engineer". The subject aroused a good deal of enthusiasm in the area. This was followed by a meeting in November when Mr. K. A. Zandstra, assisted by Mr. F. S. Smith, provided a very interesting and enlightening lecture on "The Practical Uses of Electronics in Industry". A demonstration of industrial television equipment was given at the end of the lecture.

Two applications for the Schofield Travel Scholarship have been received from Graduate Members and the applicants have now been interviewed by the Chairman and appointed members.

The members of the Section Committee are at present considering the report on the subject "Broadening of the Base", and this matter will be dealt with fully at the next meeting.

The December meeting took the form of a Film Evening and was favoured by the presence of members' ladies and their guests. This type of meeting was held for the first time by the Section in December last year and has proved very successful.

NORTHERN IRELAND REGION

Northern Ireland

The Section Programme for the current Session commenced in October when Mr. John Ringland, M.I.Prod.E., Section Chairman, gave a short talk which was followed by an interesting film on measuring equipment. Mr. L. G. Humble, M.I.Prod.E., presented his Paper entitled "Some Aspects of Work Study" in November to a capacity audience. The Belfast and District Branch of the Institute of Cost and Works Accountants was well represented at this meeting and their Vice-Chairman, Mr. J. Doran, B.Sc., F.C.W.A., A.M.I.I.A., seconded the hearty vote of thanks, which followed on completion of Mr. Humble's most excellent Paper.

G.K.N.'s film "They're Everywhere" was shown to members and their friends in December, and Mr. Taylor, who was recently on G.K.N.'s staff, answered queries which were raised at the discussion that followed the showing of the film.

NORTH MIDLANDS REGION

Leicester

The first lecture of the Session was to have been the Chairman's address, but this had to be cancelled at short notice due to Mr. Routledge leaving for the U.S.A. The lecture on "Production Milling" by Mr. A. R. Hambidge, and "Training as Related to Production Processes" by Mr. E. M. Price, provoked lively discussion.

The Second Annual Dinner was held in November, when the chief guest was Mr. G. Ronald Pryor, Chairman of Council, and the Section were again honoured by the presence of the Lord Mayor of Leicester. Mr. H. Wyndham Badger, Institution Education Officer, responded to the toast of "The Guests". Among the guests were prominent local company executives, also Dr. Haslegrave and Mr. J. France of Loughborough College.

It has been announced that Mr. S. Radcliffe, Section Vice-Chairman, has been appointed a Governor of Loughborough College.

The Section Committee will be debating the controversial subject of "Broadening of the Base" at the next meeting.

Nottingham

The theme for the lecture meeting programme this Session is "Increased Productivity", and in this connection every possible assistance has been received from the Local Productivity Committee. The attendance at meetings and visits which have taken place so far this Session has shown a marked improvement over last Session. The Section Committee consider this is due to the choice of lectures, and to the topicality of the theme to which engineers are devoting a great deal of interest. As a direct result of this, applications for membership are steadily flowing in. Members possessing the necessary qualifications and status are being encouraged to transfer to the higher grades.

A Joint Meeting with the Institute of Cost and Works Accountants will be held in January when Mr. B. G. L. Jackman, M.I.Prod.E., will talk on "The Human Aspect in Production Planning and Control".

Lincoln

During the period under review two meetings have been held in Lincoln and one at Scunthorpe. The first meeting of this Session was held in September, when Mr. E. Lloyd read a Paper by Dr. J. D. Jevons, entitled: "How the Production Engineer can be helped by the Metallurgist". The second meeting was held in the Scunthorpe area, when Mr. J. E. Hill, M.I.Prod.E., read an excellent Paper entitled, "The Institution and You".

In December Mr. F. Nixon, of Rolls-Royce Ltd., gave an excellent Paper entitled "Material Utilisation". This Paper was very well received and a very good discussion followed.

In October, the second Dinner Dance was held and the Section was very grateful for the loyal support of Head Office on this occasion.

The loss from the Section Committee of Mr. Stallard is regretted. Mr. Stallard, who relinquished his position of Works Manager of Marshall & Company Ltd., has taken up

a post in the Manchester District. He has done some excellent work for this Section in the Gainsborough area.

NORTH WESTERN REGION

Liverpool

At the first lecture meeting of this Session, Mr. J. Leigh delivered an excellent Paper on "Incentive Schemes", drawing from his considerable experience as a management consultant. A lively discussion ensued. In November, Mr. D. N. Buttrey, M.Sc., A.R.I.C., A.P.I., with the aid of many interesting slides, gave his lecture on "Shell Moulding". From the interesting discussion which followed it could be seen that the meeting had attracted members who had had no previous knowledge of the process. At the first December meeting, which was organised in conjunction with the City of Liverpool Public Libraries, an interested audience listened to Dr. E. L. Diamond, M.Sc., M.I.Mech.E., lecturing on "British Standards in Production Engineering". In general, the attendance at meetings has given the Committee great satisfaction.

The Section continues to be represented on the Merseyside and District Productivity Committee and the Warrington and District Productivity Committee.

The Section Committee has met regularly each month and three Schofield Scholarship applicants were interviewed in November.

Liverpool Graduate

Towards the end of October Mr. T. L. Henthorne resigned his position as Section Chairman and Mr. A. J. Vine was elected to fill the casual vacancy.

The Institution Secretary, Mr. W. F. S. Woodford, delivered a Paper on "Public Speaking" to the Section in October. The lecture was very well received. An additional lecture has been arranged for February, when Mr. T. Fullwood will give a Paper on "Metallurgy".

The Section's visit to C. Tinling & Co. Ltd., Bookbinders, at Prescot in November was exceptionally interesting. Applications for places on Works Visits have exceeded the limit of the number of places available.

In conjunction with other Graduate Sections, by maintaining a record of Section and individual members' activities during the session, the Committee hope to help compile statistics for the next Graduate Conference.

Manchester

The 1954/55 lecture Session has now reached the half-way stage. Three first-class lectures have been given and the average attendance has been good.

Arrangements have now been completed for the first North Western "Regional" Dinner to be held in February, and a good attendance is expected.

The Section Committee have discussed the forthcoming 1955 National Conference, and fully endorse both the theme and the proposed Discussion Papers. Full support can be expected from the Manchester Section despite the rather lengthy journey involved.

Applications for membership continue at their present level. The Section Committee have discussed the recent proposals made by the Broadening of the Base Sub-Committee with reference to "Examination Structures and Syllabus". Full agreement was reached on the questions submitted and a report has been forwarded to Headquarters.

Manchester Graduate

Each of the three lectures presented during the quarter was well received and quite good attendances were recorded. It may be significant to note that the highest attendance was at the lecture on "The Electronic Control of Machine Tools".

In October a visit to the works of Messrs. H. W. Kearns was arranged and, also in October, a party of members visited the National Gas and Oil Engine Company at Ashton-under-Lyne.

The Chairman of the Manchester Section, Mr. H. Spencer-Smith, has very kindly offered to provide a Section Chairman's Prize to the Student or Graduate of the Section who submits the best essay of the year. It is hoped that a number of members will forward their entries in 1955.

The strength of the Section Committee has been increased by the addition of two Graduates. The Committee now consists of eleven junior members and one Senior Section representative.

Preston

The first lecture of the 1954/55 Session, which took place in Blackburn, was very well attended and Mr. W. H. Hodgetts' Paper on: "The Value of Work Study to Industry" proved very interesting and instructive. A lively discussion took place in which several visitors from the local Productivity Committees took part. A Paper on "Resistance Welding Fabrication on Small Assemblies" was given by Mr. C. A. Burton, M.Inst.W., in Preston, in November, and this meeting was also well attended. The subject was admirably presented with the aid of slides, and Mr. Burton dealt adequately with the many questions, both practical and technical, brought out in the discussion.

During the period under review two new members have been co-opted to the Committee, Dr. J. Riffkin, B.Sc., M.I.Prod.E., A.M.I.Mech.E., of the Municipal College, Burnley and Mr. Greaves, A.M.I.Prod.E., of the Royal Ordnance Factory, Darwen.

SOUTHERN REGION

Oxford

The membership of the Section is steadily increasing and the Committee have been able to recommend approval of several new applications during the past months.

In October members of the Section attended the meeting arranged by the Oxford Productivity Committee, at which a Paper entitled: "We Too Can Prosper" was given by Mr. D. Graham Hutton, O.B.E. This was also attended by members of the management of local industries, and by representatives of the Trade Unions in the district.

At the November meeting of the Section a lecture on "Form in Design and its Influence upon Productivity" was given by Mr. J. Beresford-Evans, M.S.I.A. The programme for the first half of the session will be concluded with a discussion group meeting to be held in Witney.

The Chairman and the Secretary, at the invitation of the President, represented the Section at the opening of the Institution's new headquarters in October.

SCOTTISH REGION

Glasgow

During the quarter three lecture meetings and an open discussion night have been held. The lectures have proved to be of a high standard and of practical interest to the production engineer. Mailing of lecture tickets to members has been re-introduced and attendances at meetings this Session have improved considerably.

The Section Committee have met regularly and there has been a marked increase in the number of applications for membership.

A meeting of the Scottish Regional Committee was held in Stirling, when all three Scottish Sections were represented. The main item on the Agenda was that of finance and a budget for each Section was set for Session 1954/55. The question of a Regional Meeting was discussed, but the Committee were against such a meeting in view of the distances between each Section.

Members of the Glasgow Section learned with great regret of the death after a short illness of Mr. D. W. Russell, a member of the Glasgow Section Committee. Mr. Russell had given valuable service to the Glasgow Section Committee for many years and was a Corresponding Member of the Institution's Papers Committee and he will be sadly missed by all his friends and colleagues.

SECTIONS OUTSIDE THE UNITED KINGDOM

Adelaide

In September Mr. Gilbert, of Kelvinator (Aust.), Ltd., presented a lecture on "Planning for Production". "Some of the Industrial Uses of Town Gas" was the subject at the November meeting and the speaker was the Industrial Superintendent of the S. A. Gas Company, Mr. D. L. Watson, B.A.

The Annual General Meeting was held in October when Mr. C. J. Clark, Chief Engineer of Telcalmit (Aust.), Ltd., was elected Section Chairman, and Mr. F. W. Penny, Vice-Chairman. Three new Committee members were elected, and at the first Committee meeting held, it was decided to co-opt two more members.

The Education Sub-Committee of the Adelaide Section presented the Lecture for the Annual Meeting. They chose for the subject: "The Selection and Training of Production Executives". Mr. W. Gwinnett, M.I.Prod.E., prepared the first part of the lecture dealing with the need for training and the standards to be aimed for. The second part dealt with the selection and early training of young men, and was prepared and read by Mr. F. W. Penny. The third part of the lecture, given by Mr. C. J. Clark, dealt with the advanced training for men for the higher positions. The lecture brought before the Section the data collected by the Education Sub-Committee.

The Australian Council meeting was held in Melbourne in November, and this Section was represented by the Chairman and Secretary.

Bombay

At the Section Meeting held in November, Mr. S. V. Krishnamurthy, B.E., M.S., A.M.I.Prod.E., read an interesting Paper entitled "Some Considerations in the Design and Construction of Dies for Sheet Metal Presswork". The Meeting was well attended and a lively discussion followed.

In December Mr. E. A. Brackley, A.M.I.Prod.E., read a very comprehensive Paper on the "Manufacture of Tin Cans". After a short "question time", a film showing the manufacture of cans in a plant equipped for fully automatic line production was screened. The lecture matter was demonstrated by a visit to the factory of the Metal Box Co., of India, which also took place in December.

A Special Section Meeting was held in December when a Paper entitled "Non-destructive Flaw Testing Equipment" was read by Mr. Reiser, Dipl. Ing., who was on a short visit to Bombay.

Canada

The 1954/55 programme commenced with a visit to the Anaconda American Brass Company in New Toronto, in October. Members were able to follow the manufacture of brass and copper from the initial stages to the finished product and the visit was very successful.

In November, Mr. Currie of the Jones and Lamson Machine Company talked about high speed turning. He showed an excellent film illustrating turning at speeds up to 2,400 feet per minute.

Melbourne

The Twelth Annual General Meeting of the Melbourne Section was held in October, when Section Officers and Committee were elected for the ensuing twelve months. Mr. C. Pullen, M.I.Prod.E., was elected Chairman and Mr. E. J. Herbert, M.I.Prod.E., Vice-Chairman.

After the General Meeting a Paper was presented by Mr. C. Halik, Manager of Pauer & Co. Pty., Ltd. The title of this Paper was "A Lifetime with Machine Tools", and the members thoroughly enjoyed this resumé.

The Melbourne Section held a most successful Annual Dinner in November at Union House, Melbourne University. The guest speaker was Mr. E. P. Eltham, B.E., A.M.I.E., (Aust.), whose subject was "Impressions of Training Techniques Abroad"; 120 members and their friends attended this Dinner, which was the most successful held to date.

South Africa

In October, Mr. F. H. Stokes delivered a Paper on "Modern Contracting Equipment". In November, a lecture on "The Installation of Budgetary Control and Standard Costing in Industry", was presented by Mr. D. J. Corbett, when details of the various methods of installing the system were given.

The South African Institute of Welding invited members of the South African Branch of the Institution of Production Engineers to a Paper on "Tabular Structures and Manipulated Pipework", presented by Mr. T. H. Hunter in November.

A Film Evening was held in December, when films from the Film Library of Messrs. Stewarts and Lloyds of South Africa Limited were presented and attracted a record attendance.

In November, a visit was arranged to the showrooms of Messrs. Cooke, Troughton and Simms Limited, manufacturers of surveying instruments, microscopes and optical tools, etc. The visit was well attended and proved to be of considerable interest.

During the quarter the South Africa Council and the Membership and Papers Committee met on three occasions.

Sydney

The Lecture programme for the Session ended in September, with a lecture on "The Significance of Machine Tools in the Australian Economy", given by Mr. H. Grafton, Lecturer in Production Engineering at the New South Wales University, and an excellent discussion followed.

The Annual General Meeting took place in October, and the Section Officers for the next Session were elected, Mr. J. Ogden being elected Chairman. At the conclusion of business an address was given by the retiring President, Mr. J. E. Strick.

The year's activities closed with an Institution Dinner in November, and 105 members and friends had a very enjoyable evening. Professor J. P. Baxter, Director of the University of Technology, Professor of Chemical Engineering, Deputy Chairman of Australian Atomic Energy Commission, was the Guest of Honour, and gave a very witty and enlightening address on his conception of life in the year 2000 A.D. should all subsequent scientific developments be used for the benefit of mankind.

O.M.A. Conference

A Spring Conference for executives with office management responsibilities is again being organised by the Glasgow and West of Scotland Branch of the Office Management Association, on the lines of their successful Conference held last year This Conference, which will take place on 15th, 16th and 17th April, 1955, is open to all members and subscribers of the Association and delegates from industry and commerce. The subject chosen is "Office Conditions and Remuneration" and the chief speaker will be Mr. O. W. Standingford, F.I.I.A., F.O.M.A., Financial Controller of John D. Francis, Ltd., Liverpool, and previously Assistant Comptroller of J. Lyons & Co. Ltd.

Full particulars of the programme may be obtained from the Conference Secretary, Mr. H. A. McGeorge, O.B.E., A. F. Stoddard & Co. Ltd., Glenpatrick Carpet Works, Elderslie, Renfrewshire.

HAZLETON MEMORIAL LIBRARY

Owing to heavy pressure on space in this issue, Reviews and Abstracts are being held over until April.

Sir Henry Spurrier, M.I.Mech.E., M.I.Prod.E.

Members will have noted with interest that this well-known member of the Institution, and a prominent figure in the motor industry, has been created a Knight Bachelor.

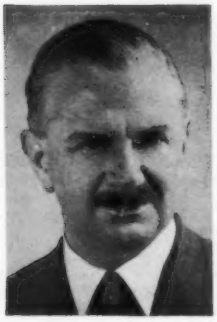
Sir Henry Spurrier, who is Managing Director of Leyland Motors, Limited, was born into the motor industry, his father being the founder of Leyland Motors, Ltd., and his grandfather its first Chairman. He is a director of other companies associated with Leyland, including British United Traction, Ltd., Self-Changing Gears, Ltd., and Commonwealth Engineering Co. Ltd. He is a member of the National Advisory Council of the Motor Industry, and was President of the Society of Motor Manufacturers and Traders from 1952 to 1953.

Mr. George B. Foote, Member, has been appointed Managing Director of Southern Aluminium Limited, Sydney, Australia. He was formerly General Manager.

Mr. S. W. A. Bunker, Associate Member, has recently been appointed Supply Manager to Teddington Refrigeration Controls Ltd., a subsidiary of The British Thermostat Co. Ltd.

Mr. C. V. V. Chetti, Associate Member, has been appointed Principal, Tamilnad Polytechnic, Madura, South India.

Mr. P. K. Digby, Associate Member, has relinquished his appointment as Production Controller of the Aircraft Division, Bristol Aeroplane Co. Ltd., and is now Staff Tutor at the Institute for Engineering Production, University of Birmingham. He will be covering the subjects of Planning, Production and Management Controls with Procedural Analysis.



Mr. James Ekins, Associate Member, has taken up his duties as Lecturer in Management Studies in the Department of Commerce and Management, at The College of Commerce and Technology, Sheffield. Mr. Ekins was formerly Production Controller with The Birtley Co. Ltd., Birtley, Co. Durham.

Mr. J. G. Elting, Associate Member, has recently relinquished his appointment with British Light Steel Pressings Ltd., and has now taken up a position as Production Engineer with Ultra Electric Limited, Acton.

Mr. D. Gemmell, Associate Member, has now taken up the position of General Works Manager of Metind Limited, Birkenhead.

Mr. W. H. Hooper, Associate Member, has taken up an appointment as General Works Manager with James A. Jobling & Co. Ltd., Sunderland.

Mr. A. O. Mattocks, Associate Member, has taken up a position as General Works Manager, Saunders-Roe (Anglesey) Ltd. He was previously Production Engineer, Saunders-Roe Ltd., East Cowes, Isle of Wight.

Mr. O. G. C. Mears, Associate Member, has now relinquished his post at Chippenham Technical College and has been appointed Senior Lecturer in Production Engineering in the Department of Production Engineering and Management at the Wolverhampton and Staffordshire Techincal College.

Mr. F. C. Munns, Associate Member, has been promoted Engineer II in charge of Development at R.O.F., Nottingham.

Mr. W. A. Parr, Associate Member, has recently been appointed Local Director and Works Manager of The Sanbra Engineering Company, Birmingham, where he was previously Works Manager and Production Engineer.

Mr. C. J. Pearce, Associate Member, has been appointed Works Manager of Flight Refuelling Limited, Blandford, Dorset, where he was previously Production Engineer in charge of Works.

Mr. O. H. Willey, Associate Member, late of John Lysaght Ltd., Bristol, has now been appointed Director and General Manager of the British Industrial Engineering Company (Staffs) Limited, Tipton, Staffs.

Mr. P. C. Felton, Graduate, has relinquished his post as Planning Engineer to Vickers-Armstrongs Ltd,. Weybridge, and has now taken up an appointment as a Production Engineer with Ronson Products Ltd., Leatherhead, Surrey.

Mr. A. W. Markham, Graduate, has taken up a position as Assistant Mill Manager at the Birmingham Battery & Metal Company Ltd.

Mr. D. J. I. Gray, Graduate, has been appointed Production Controller of Booth, MacDonald & Co. Ltd., Christchurch, New Zealand, where he was formerly Works Manager of the Christchurch factory. As Production Controller, Mr. Gray will be responsible for production engineering aspects at both the Christchurch and Penrose, near Auckland, factories.

The Council of the Institution

1954/55

President
Sir Walter Puckey

Vice-President and President Elect
Sir Leonard Lord, K.B.E.

Chairman of Council
G. R. Pryor

Vice-Chairman of Council
H. G. Gregory

Immediate Past Chairman of Council
H. Burke

Past Presidents

Major-General K. C. Appleyard, C.B.E. Sir George Bailey, C.B.E. Sir Alfred Herbert, K.B.E. Norman Rowbotham, C.B.E. The Rt. Hon. Viscount Nuffield, G.B.E. J. D. Scaife Dr. H. Schofield, C.B.E. The Rt. Hon. Lord Sempill, A.F.C. Tom Thornycroft Sir Cecil Weir, K.C.M.G., K.B .E., D.L., M.C.

Presidents of Councils outside the United Kingdom

AUSTRALIAN COUNCIL—J. N. Kirby
SOUTH AFRICAN COUNCIL—W. G. Gillespie

Chairmen of Regional Committees

East & West Ridings
J. E. Hill
Eastern
J. B. Webster
Midlands
H. Burke
North Midlands
J. C. Routledge
Northern
T. McCulloch
North Western
F. W. Cranmer
Northern Ireland
J. Ringland
Scotland
M. C. Timbury
South Eastern
R. E. Leakey
Southern
F. T. West, M.B.E.
South Western
E. F. Gilberthorpe
Wales
W. H. Folds

Additional Representatives on Council

East & West Ridings
F. T. Nurrish, M.B.E.
Midlands
S. J. Harley
North Western
J. France
South Eastern
R. Telford

Chairmen of Standing Committees

K. J. Hume B. H. Dyson R. E. Mills C. L. Old S. A. J. Parsons M. Seaman
The Rt. Hon. Lord Sempill, A.F.C.

Elected Members

A. J. Aiers H. W. Bowen, O.B.E. R. S. Brown R. M. Buckle A. G. Clark R. S. Clark Wm. Core B. H. Dyson E. P. Edwards F. J. Everest R. S. Hind B. G. L. Jackman R. Kirchner Prof. T. U. Matthew B. E. Stokes A. L. Stuchbery C. Timms R. H. S. Turner

Co-opted Member

T. Fraser, C.B.E.

Chairmen of Sections outside the United Kingdom where Councils are not established

Bombay
J. V. Patel
Canada
C. J. Luby
Calcutta
B. F. Goodchild
N. Zealand
E. Paton

Overseas Councils

AUSTRALIA

President
J. N. Kirby

Chairman
C. Pullen

Vice-Chairman
J. O. Ogden

Elected Members

C. J. Clark R. W. Deutsher S. Downie N. Eaton N Esserman W. M. B. Fowler W. Gwinnett W. L. Hemer E. Herbert J. H. Law J. Steer J. E. Strick H. G. Sutton A. Welsh L. W. Worthington

SOUTH AFRICA

President
W. G. Gillespie

Vice-President
H. J. G. Goyns

Past Presidents

B. Anderson R. H. Arbuckle L. H. L. Badham G. Godfrey J. Henry D. Lion-Cachet J. Renwick A. C. Wotherspoon

Elected Members

G. T. Chawner D. N. S. Clare V. J. S. Donnelly C. O. Doehring D. E. Hamm D. A. Petrie G. M. Pratley
P. L. Ward H. H. Waters

REGIONAL HONORARY SECRETARIES

East & West Ridings	...	Miss N. E. Bottom	**Northern Ireland**	...	W. G. Wyman
Eastern	...	L. A. Childs	**Scotland** ...	...	W. H. Marley
Midlands	...	B. W. Gould	**South Eastern**	...	R. Hutcheson
North Midlands ...	...	D. G. Swinfield	**Southern** ...	...	J. W. Taylor
Northern	...	C. C. Hodson	**South Western**	...	A. Eustace
North Western ...	...	G. R. Parker	**Wales** ...	...	J. Bolwell

Secretary of the Institution
W. F. S. Woodford

SECTION CHAIRMEN

C. J. Clark	Adelaide	T. McCulloch	North Eastern
T. W. Elkington	Birmingham	J. Ringland	Northern Ireland
J. V. Patel	Bombay	W. J. Ford	Norwich
B. F. Goodchild	Calcutta	L. Shenton	Nottingham
C. J. Luby	Canada	L. P. Coombes	Oxford
H. M. Sawyer	Cornwall	H. F. Adams	Peterborough
S. J. Harley	Coventry	E. G. Eaton	Preston
A. Short	Derby	T. H. Christy	Reading
G. R. Whitehead	Doncaster	W. Hodgkisson	Rochester
A. Williamson	Dundee	E. Levesley	Sheffield
E. N. Farrar	Eastern Counties	P. G. Garside	Shrewsbury
Dr. A. F. Muir	Edinburgh	W. G. Gillespie	South Africa
M. C. Timbury	Glasgow	R. Telford	South Essex
T. E. Love	Gloucester	W. H. Folds	South Wales
F. J. Everest	Halifax	F. T. West, M.B.E.	Southern
J. C. Routledge	Leicester	H. Porter	Stoke-on-Trent
R. S. Hind	Lincoln	J. O. Ogden	Sydney
J. France	Liverpool	R. H. Archer	Tees-side
R. E. Leakey	London	W. H. Bowman	West Wales
R. M. Buckle	Luton	E. F. Gilberthorpe	Western
H. Spencer Smith	Manchester	C. L. Old	Wolverhampton
C. P. Pullen	Melbourne	R. H. Higgs	Worcester
E. Paton	New Zealand	D. H. Turnbull	Yorkshire

GRADUATE SECTION CHAIRMEN

W. Silberbach	Birmingham Graduate	J. P. Speakman	Manchester Graduate
L. B. Rutter	Coventry Graduate	G. D. Robson	North Eastern Graduate
J. Taylor	Halifax Graduate	E. Willcox	Sheffield Graduate
A. J. Vine	Liverpool Graduate	C. H. Spearing	Western Graduate
F. H. Johns	London Graduate	E. J. V. Connelly	Wolverhampton Graduate
M. J. Hemmett	Luton Graduate		Yorkshire Graduate

SECTION HONORARY SECRETARIES

AUSTRALIA

Adelaide (South Australia)	...	W. L. Hemer, 6 Bedford Street, Brooklyn Park, South Australia.
Melbourne (Victoria Australia)	...	R. W. Deutsher, Bank House, 11 Bank Place, Melbourne, C.I., Victoria Australia.
Sydney (N. S. Wales) ...	...	A. Welsh, Room 802, 16 Barrack Street, Sydney, Australia.

CANADA

Canada ... ... P. M.Wood, 31 Conway Avenue, Toronto, 10, Ontario.

INDIA

Bombay	E. Fernandes, c/o Burmah Shell, Royal Insurance Bldg., 14 Jamshedi Tata Rd., Churchgate, Bombay.
Calcutta	N. N. Sen Gupta, 110 Surrendra Nath, Banerjee Road, Calcutta 13.

NEW ZEALAND

New Zealand	H. R. Holmes, Pah Road, Papatoetoe, Auckland.

SOUTH AFRICA

South Africa	The Secretaries, Institution of Production Engineers, Barclays Bank Buildings, Corner Commissioner and Harrison Streets, Johannesburg.

UNITED KINGDOM

Birmingham	B. W. Gould, Dept. of Industrial Administration, College of Technology, Suffolk Street, Birmingham.
Cornwall	F. G. Hawke, 17 Church Road, Pool, Redruth, Cornwall.
Coventry	W. G. Key, 128 Green Lane, Coventry.
Derby	P. Warburton, 27 Albemarle Road, Chaddesden, Derby.
Doncaster	W. H. Edwards-Smith, "Hindcarth" Melton Road, Sprotborough, Nr. Doncaster.
Dundee	K. Fairweather, 82 Carlochie Place, Dundee, Angus.
Eastern Counties	A. B. Brook, Davey, Paxman & Co. Ltd., Britannia Works, Colchester.
Edinburgh	(Acting) Dr. A. F. Muir, 18 Sidney Terrace, Edinburgh 7.
Glasgow	W. H. Marley, G. & J. Weir, Ltd., Coltness Foundries, Newmains, Lanarks.
Gloucester & District	C. L. Mawhood, 43 Rosehill Street, Cheltenham, Gloucester.
Halifax	Miss N. E. Bottom, Hopkinsons Ltd., Huddersfield.
Leicester & District	D. G. Swinfield, 65 St. Saviour's Road, Leicester.
Lincoln	H. Wright, 101 Longdales Road, Lincoln.
Liverpool	R. T. Spencer, 44 The Beech Walk, Knottyash, Liverpool 14.
London	R. Hutcheson, Machine Shop Magazine, Dorset House, Stamford St,, London, S.E.1
Luton	J. F. W. Galyer, Engr. Dept., Luton & South Beds. College of Further Education, Park Square, Luton.
Manchester	G. R. Parker, 101 Green Lane, Garden Suburbs, Oldham.
North Eastern	A. C. Foskew, 35 Oakwood Avenue, Low Fell, Gateshead, 9.
Northern Ireland	W. G. Wyman, "Linden Lea", Cultra, Co. Down, N. Ireland.
Norwich	F. H. S. Heidenstam, 33 Cecil Road, Norwich.
Nottingham	C. N. T. Manfull, Chellaston House, Thurgarton Street, Nottingham.
Oxford	M. J. Inston, 53 Rymers Lane, Cowley, Oxford.
Peterborough	E. G. Perrett, 165 St. Pauls Road, Peterborough.
Preston	R. Thompson, 71 Willows Lane, Accrington, Lancs.
Reading	R. W. H. Mark, "The Beeches", 41 Reading Road, Woodley, Berks.
Rochester & District	W. G. Clements, 11 Charing Road, Gillingham, Kent.
Sheffield	T. F. Newton, 20 Exley Avenue, Sheffield 6.
Shrewsbury	W. M. Buchan, Llanberis, Mytton Oak Road, Shrewsbury.
Southern	J. W. Taylor, 44 Deacon Road, Bitterne, Southampton.
S. Essex	P. H. W. Everitt, 6 Hillcrest Road, Loughton, Essex.
South Wales & Mon.	J. Bolwell, Creed & Co. Ltd., Treforest Trading Estate, Pontypridd, Glamorgan.
Stoke-on-Trent	R. Rowley, North Staffordshire Technical College, Stoke-on-Trent.
Tees-side	T. A. Horsley, 24 Clarence Road, Nunthorpe, Nr. Middlesbrough.
Western	A. Eustace, 19 Ferndale Road, Northville, Bristol 7.
West Wales	H. P. Sanderson, I.C.I. Ltd. (Metals Division), Waunarlwydd, Nr. Swansea.
Wolverhampton	R. J. Sury, Wolverhampton and Staffordshire Technical College, Wolverhampton.
Worcester	R. Wheeler, Old Farm House, Parish Hill, Bournheath, Nr. Bromsgrove, Worcs.
Yorkshire	J. L. Townend, 26 Moor Allerton Drive, Street Lane, Leeds 17.

CORRESPONDING MEMBER IN MIDDLE EAST

J. Merkine, 45 Arlozoroff Street, Ramat-Gan, Israel.

CORRESPONDING MEMBER IN EGYPT

A. F. Abdo, 29 Abo Taleb Street, Terha Bolackia, Shouba, Cairo.

CORRESPONDING MEMBER IN BRITISH W. AFRICA

H. P. Halfter, Gold Coast Rlys. and Harbour Admin., P.O. Box 202, Takoradi, Gold Coast, B.W.A.

GRADUATE SECTION HONORARY SECRETARIES

Birmingham	R. D. Guthrie, 90 Park Road, Quarry Bank, Brierly Hill, Staffs.
Coventry	A. S. Hopkins, 39 Oaks Road, Kenilworth, Warwicks.
Halifax	C. W. Overin, 353 Whitehall Road, Westfield, Wyke, Nr. Bradford.
Liverpool	G. L. Smith, 17 Withers Street, Liverpool 7.
London	R. U. Shaw, 29 Goldcroft, Bennetts End, Hemel Hempstead, Hertfordshire.
Luton	F. G. Ethelston, c/o 106 Argyll Avenue, Luton, Beds.
Manchester	D. Allott, 47 Williams Crescent, Chadderton, Nr. Oldham, Lancs.
North Eastern	R. F. Loebl, 32 Deneside Avenue, Low Fell, Gateshead-on-Tyne 9.
Sheffield	G. Shaw, Horseshoe Cottage, Holmesfield Road, Nr. Sheffield.
Western	R. W. Wall, 6 Filton Avenue, Horfield, Bristol 7.
Wolverhampton	W. L. Pace, "Linden", 10 Ezekiel Lane, Short Heath, Willenhall, Staffs.
Yorkshire	

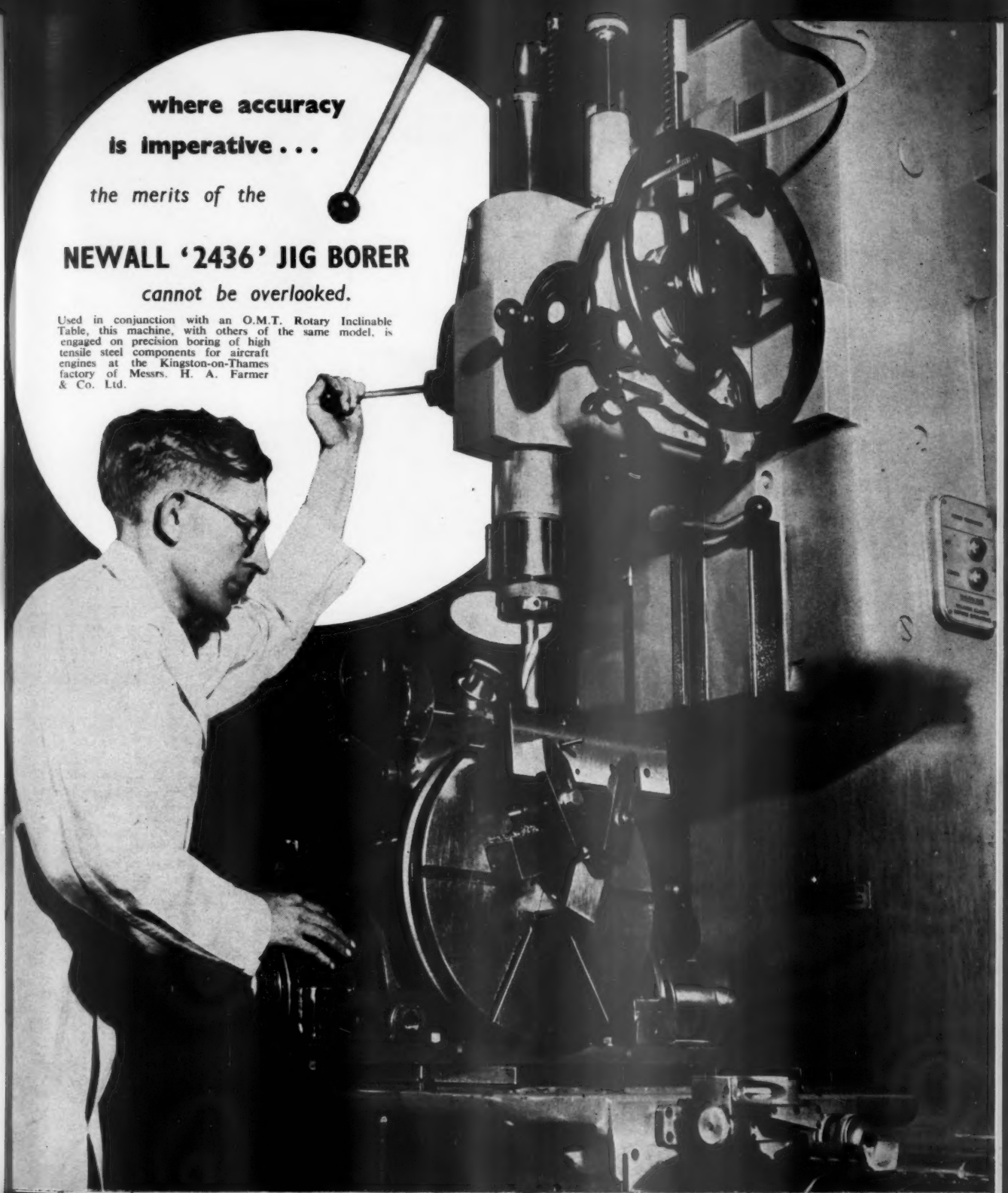
where accuracy is imperative . . .

the merits of the

NEWALL '2436' JIG BORER

cannot be overlooked.

Used in conjunction with an O.M.T. Rotary Inclinable Table, this machine, with others of the same model, is engaged on precision boring of high tensile steel components for aircraft engines at the Kingston-on-Thames factory of Messrs. H. A. Farmer & Co. Ltd.



BRITAIN'S LARGEST MANUFACTURERS OF JIG BORERS

NEWALL

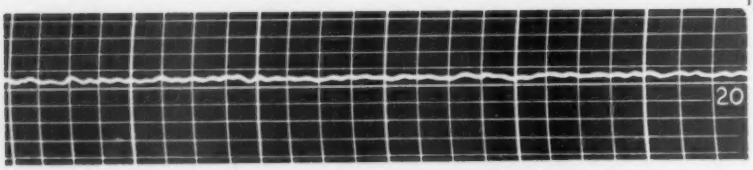
NEWALL GROUP SALES LTD

PETERBOROUGH

TELEPHONE 3227/8/9

Stanley Howard says....

THIS LAMB'S WOOL FIBRE HAS BEEN MAGNIFIED 1,000 TIMES



AND THAT'S ONLY ONE-FORTIETH THE MAGNIFICATION OF THIS SURFACE DEPTH VARIATION PRODUCED BY A

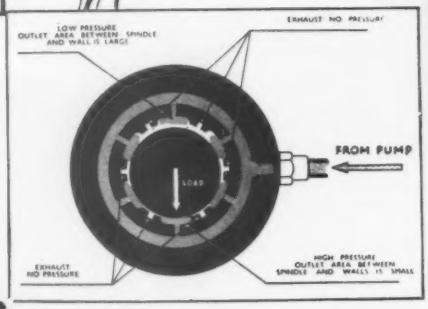
Gendron Freres

External and Universal Grinding Machine

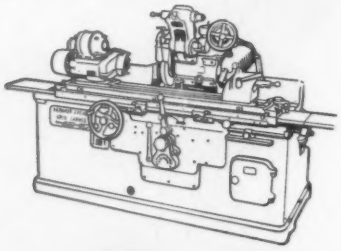
The specimen illustrated above gave a "TALYSURF" reading of .4 μ (centre line average) with a vertical magnification of 40,000 and a horizontal magnification of 200.

But that's not all—a "TALYROND" check of the same specimen gave a result of only .00001" out of roundness.

Further information can be obtained from the Sole Distributors →



The "heart" of this amazing machine is the "fluid bearing" of the "GERRARD" grinding head in which different pressures are built up in adequate areas, the variation of these pressures being controlled only by the position of the spindle in relation to its bearing, regardless of angular velocity.



STANLEY HOWARD LTD
75-76, EXCHANGE BLDS.
STEPHENSON PLACE · BIRMINGHAM 2
Tel: MIDland 6915

BUSINESS MACHINES BY

THE National

CASH REGISTER COMPANY

POWER PRESSES BY HME

This line of H.M.E. Open Front Presses, installed at the National Cash Register Company's Dundee works, is producing a multiplicity of intricate components for the latest types of business machines.

Our Technical Representative will be pleased to help and advise you regarding the range of H.M.E. Open Front and Double Sided Presses from 3 to 300 tons capacity.

HORDERN, MASON & EDWARDS LTD.

LET DUCKHAM'S SOLVE YOUR CUTTING OIL PROBLEM

To the achievement of the production engineers' target of *maximum production per machine hour* Duckham's can make valuable contributions. Selected from our range of cutting fluids are the following—they reflect all that is best in modern machine shop practice.

DUCKHAM'S TRANSCUT 50

A recently developed clear type soluble oil with considerable advantages to economical production. It has higher dilution strength than normal type soluble oils; it is completely stable; it provides maximum cooling effects; it brings under control that machine shop nightmare — rust.

DUCKHAM'S X.D SULFCUT

A general purpose neat cutting oil, pale type, suitable for auto machining of mild steel up to 50/60 tons tensile.

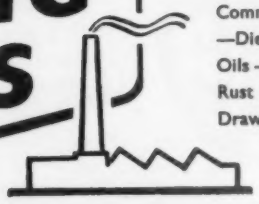
DUCKHAM'S TRANSCUT 130

A semi-opaque type soluble cutting oil containing an extreme pressure additive to cope with the machining difficulties of tough aircraft steels and high nickel content alloys.

The assistance of our technical staff is freely available to help with problems arising out of the use of cutting fluids, machine tool lubrication and allied matters.

Duckham's

CUTTING FLUIDS



Our booklet entitled "Cutting Fluids and Machine Shop Lubricants" is available on request. Please write to

Dept. CMI., ALEXANDER DUCKHAM & CO. LTD., HAMMERSMITH, W.6. or 'phone FULham 3300.

Duckham's manufacture a complete range of oils and greases for all purposes, including — Commercial Vehicle Oils — Compressor Oils —Diesel Engine Oils—Gear Oils—Refrigerator Oils — Steam Turbine Oils — Tractor Oils — Rust Preventives — Press Compounds — Wire Drawing Lubricants, etc.

NOL MOTOR OILS

—premier grade engine and transmission oils providing lubrication at its best. NOL Motor Oils are specified by Austin, Ford, Jowett, Standard, M.G., Morris, Triumph, Riley, Rover and Wolseley cars.

Duckham's NOL MOTOR OILS

(A-S-C) ANTISEPTIC SKIN CLEANSER

—a speedy, effective cleanser of greasy, grimy, pore-clogged hands. A-S-C is easy to use and leaves the skin thoroughly clean and the hands soft, smooth and germ-free

PRESENTING — another fast worker!...

THE NEW No. 12 SCREWDRIVER

Here's a light-weight tool with a really big capacity . . fast, compact and versatile, it has increased motor power and a new handle shaped for more finger room. Ideal for a variety of assembly jobs, it drives up to No. 12 x 2" wood, and up to ¼" self-tapping and machine screws and is equally useful for light nut-running. Available in two models, Positive and Double Clutch, the New No. 12 Screwdriver is made by the world's largest manufacturers of portable electric tools for all industries. Other Black & Decker tools include Sanders, Saws, Drills, Hammers, Bench & Portable Grinders.

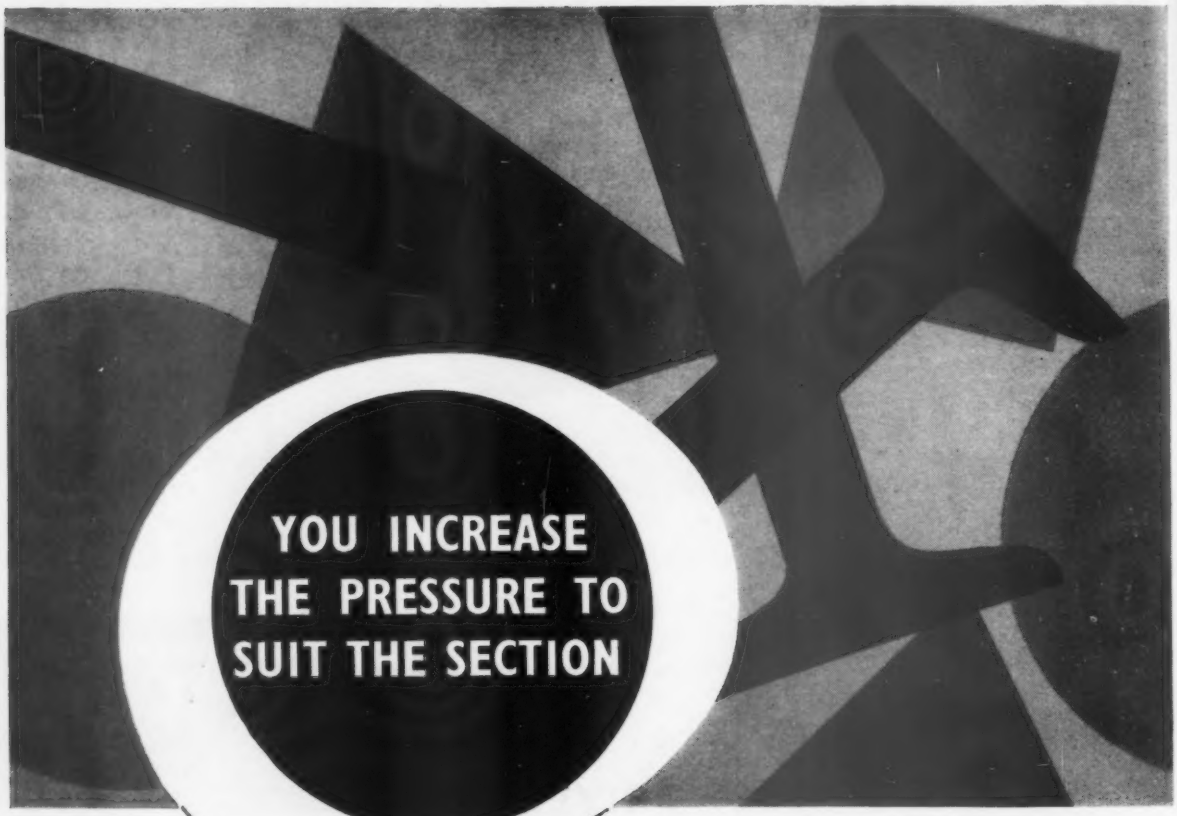
A Black & Decker Screwdriver being used as a light nut runner for the assembly of the Sturmey Archer Hub at the Raleigh Cycle Co.

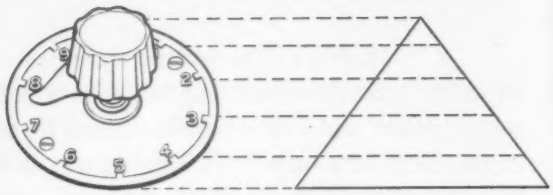
Quicker and Better with

Black & Decker

PORTABLE ELECTRIC TOOLS

Write for catalogue. Demonstration of any tool on request. **BLACK & DECKER** LTD · HARMONDSWORTH · MIDDLESEX
TOWSON, U.S.A. · TORONTO, CANADA · SYDNEY, AUSTRALIA · MEXICO, D.F. · SAO PAULO, BRASIL
Smee's





AND THAT'S WHAT THE

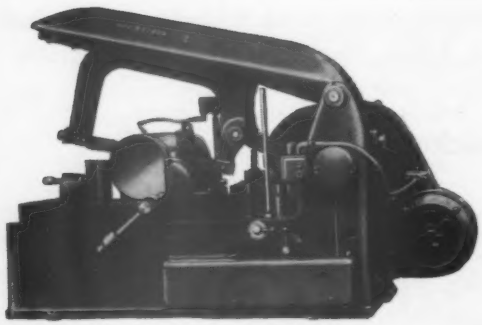
WICKSTEED

HYDRAULIC CONTROL SAWING MACHINE

WILL DO FOR YOU WITH BLADES OF ONE PITCH OF TOOTH

The blade commences and finishes each cutting stroke with no pressure whatsoever. What a saving in blades!

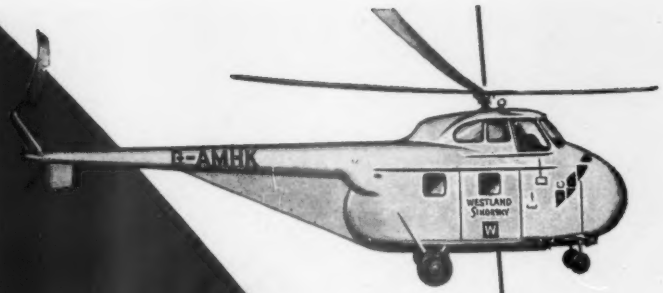
FAMOUS FOR SPEED, ACCURACY AND RELIABILITY



Models for capacities 6" x 6" to 12" x 12"

SEND FOR DETAILS TO :

CHARLES WICKSTEED & CO. (1920) LTD. · STAMFORD ROAD WORKS, KETTERING · TEL.: 3113-4



It all hangs on ELEKTRON

ELEKTRON

Magnesium Elektron Limited

CLIFTON JUNCTION, MANCHESTER LONDON OFFICE 21 ST. JAMES'S SQUARE, S.W.1

for our *NEW* booklet D.8 *on* "DESIGN"

MILLS

GROOVED PINS

Mills Grooved Pins have proved themselves efficient and economical in over a hundred different types of industry, and are being used in increasing numbers. Made in twelve different types they eliminate reamering and tapping, are easy to fit, and will not vibrate loose.

Please let us send you samples and catalogues

Safe – Simple – Satisfactory

DRILL & DRIVE HOME!

EXORS. OF JAMES MILLS LTD.

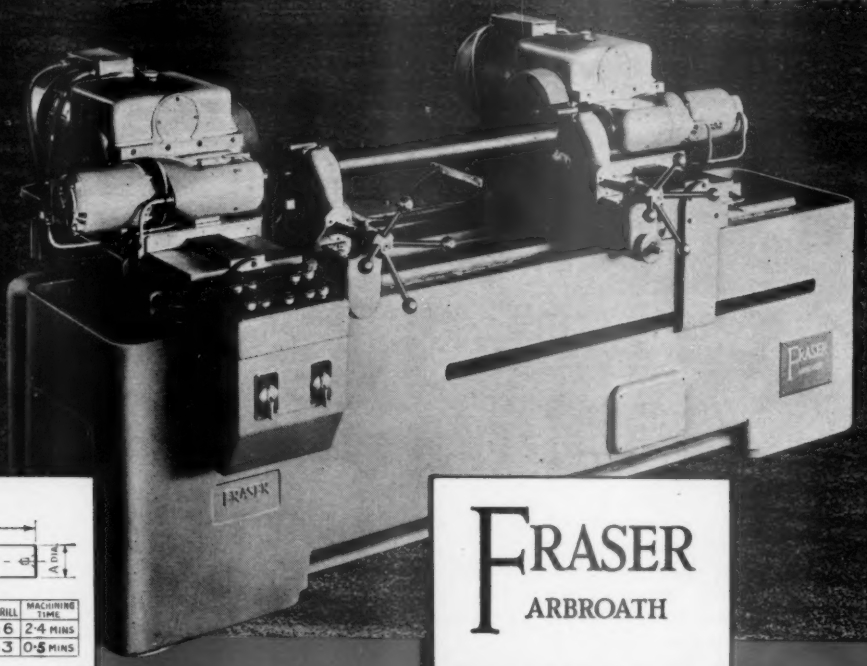
BREDBURY STEEL WORKS

WOODLEY · NEAR STOCKPORT · ENGLAND

Telephone : WOODLEY 2231 (10 lines) Telegrams : "MILLS" PHONE WOODLEY

a NEW speedier simpler Facing & Centring Machine

(DOUBLE-ENDED)



FRASER
ARBROATH

- Automatic Cycle Machining.
- Mills and centres components, perfectly and accurately.
- Prepares components for work on Lathes, or in conjunction with Copying Lathes. Ideal for small batches and long production runs.
- Self centring vices for any diameter.
- Electro-hydraulic controls. Fast, simple operation.
- All important parts easily accessible.
- It is possible to supply machines to take 9 feet between cutters.

SPECIFICATION

Maximum Diameter ... 6½"
Minimum Diameter ... ⅜"
Maximum Length ...5' 0"
Minimum Length ... 6½"
Fast Traverse and Return—150 feet per minute.

Write for leaflet PE. 754

SOLE AGENTS

SIDNEY JONES

SIDNEY G. JONES LTD., 8, Balham Hill, London, S.W.12. BATterSea 3246

① B, A DIA

	A DIA	B	C/DRILL	MACHINING TIME
MAX.	6¼"	5'0"	No 6	2·4 MINS
MIN.	¾"	6½"	No 3	0·5 MINS

② MACHINING TIME 0·8 MINS
ALL DIMENSIONS AS No 1

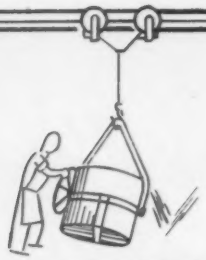
③ B, A DIA

	A DIA	B
MAX.	6 ⅛"	INF.
MIN.	¾"	2"

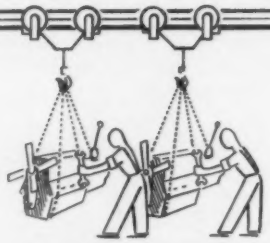
OTHER DIMENSIONS AS No 1

④ MACHINING TIME 0·9 MINS.

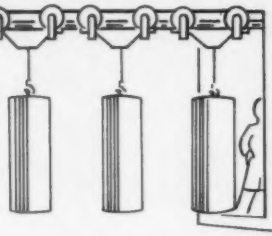
⑤ MACHINING TIME 1 MIN.



Engineered to provide complete flexibility of application in most industries, British MonoRail overhead handling systems are designed for the intermittent movement of materials and transfer of loads up to 5,000 lbs. along fixed paths on or between varying floors or levels.

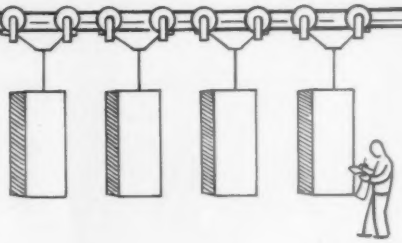


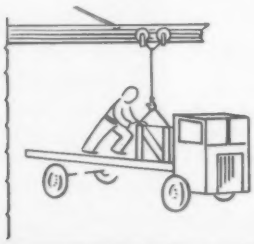
In machine and assembly shops, stores, etc., British MonoRail equipment provides time saving inter shop transfer and accurate load positioning over wide areas without the necessity for hook or carrier changes. Spur tracks, connecting through switches provide 'on the line' storage if required.



Where weighing, dipping, spraying and finishing processes, etc., are required to be accomplished without load transfer from the original carrier, sections may be incorporated in track layouts for these operations.

Complete manually or power operated systems engineered to your specific requirements. Our engineers will be pleased to show you how British MonoRail equipment can solve your handling problems.





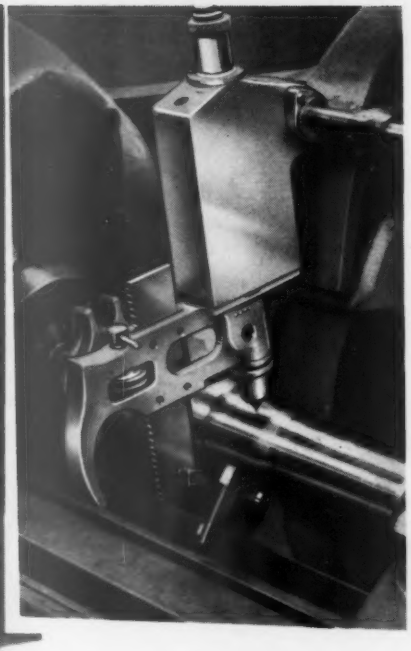
Write for catalogue BMH/2.

BRITISH **MonoRail** LIMITED

WREN WORKS · CHADDERTON · LANCASHIRE

TELEPHONE: MAIn (Oldham) 5691

AUTO-SIZING *the* PRECIMAX *way*



'STOP-CUT' UNIT

'STOP-CUT'

ELECTRONIC EQUIPMENT

applied to "Precimax" Cylindrical Grinders at John Holroyd & Co. Ltd., Rochdale.

— ***GIVES CONSISTENT REPETITIVE PRECISION***

LIMITS OF ACCURACY ±0.00004" (FOUR HUNDRED THOUSANDTHS) ARE EASILY ATTAINABLE.

Fine Boring Machines. Fine Boring Heads (Units).
Plain and Universal Cylindrical Grinding Machines. Finegrinders
Surface Grinding Machines—
With vertical or horizontal grinding wheel spindles and with work-tables having rotary or reciprocating linear traverse movement.
Special Grinding Machines—
For crankshaft journals, camshafts, pistons, etc.

John Lund Ltd.

CROSS HILLS • KEIGHLEY • YORKS

MAKERS OF RADIAL, UNIVERSAL & VERTICAL DRILLING M/CS.

MULTI-SPINDLE UNIT HEADS.

FLOOR TYPE BORING, DRILLING, & MILLING M/CS.

WILLIAM ASQUITH LTD., HALIFAX, ENG.

LONDON OFFICE : HALIFAX HOUSE, STRAND, LONDON, W.C.2.

Sales and Service . . . **DRUMMOND-ASQUITH** *. . in the British Isles.*

DRUMMOND-ASQUITH (SALES) LTD., KING EDWARD HOUSE, NEW ST., BIRMINGHAM
'Phone: Midland 3431 (5 lines) *Also at LONDON: 'Phone: Trafalgar 7224 (3 lines), and GLASGOW: 'Phone Central 3411*

Andersen

Sales and Service in the British Isles
DRUMMOND-ASQUITH (SALES) LTD. KING EDWARD HOUSE, NEW ST. BIRMINGHAM
Phone: Midland 3431 (5 lines) Also at: LONDON, phone: Trafalgar 7224 (3 lines). GLASGOW, phone: Central 3411

PRODUCTION TUBE BENDING TO A NEW STANDARD

Hydraulic operation. Tubes bent cold and unloaded. Accurate bends without wrinkles. Automatic clamping and ejection. Minimum setting times. High production rates.

The STAFFA No. 1
Production Tube Bending Machine.
Full particulars on request.

Staffa
TRADE MARK

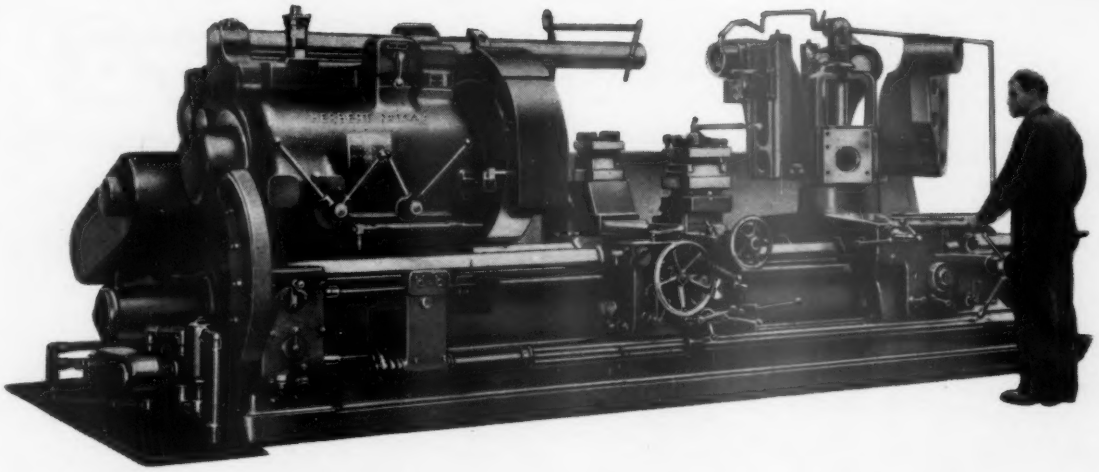
PRODUCTION
TUBE BENDING MACHINES

Sales & Service . . . **DRUMMOND-ASQUITH** *. . . in the British Isles*

DRUMMOND - ASQUITH (SALES) LTD., KING EDWARD HOUSE, NEW STREET, BIRMINGHAM
'Phone: Midland 3431 (5 lines) *Also at LONDON: 'Phone: Tarfalgar 7224 (3 lines) and GLASGOW: 'Phone Central 3411*

Anderson

HERBERT



HERBERT No. 14/36 COMBINATION TURRET LATHE

SWING OVER BED 36″ · HOLE THROUGH SPINDLE 8½″

THIS fine machine will deal with the heaviest turret lathe work; it is remarkable for durability and ease of operation. A number of safety devices incorporated in the design prevent any possibility of damage to either machine or operator.

The hardened and ground vees of the bed are protected by sliding covers at the headstock end.

The spindle runs in precision type ball and roller bearings.

All shafts in the headstock run in ball bearings, lubrication is automatic.

Automatic feeds to turret and saddle are independent.

Quick-power motion to longitudinal and cross traverse of saddle and to the turret travel in both directions.

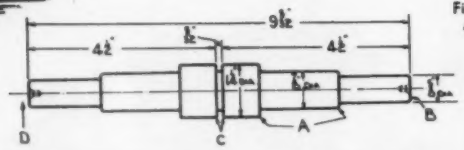
Chasing motion is included, taper attachment can be fitted.

EARLY DELIVERY

FULL PARTICULARS ON REQUEST FROM :—
HEAD WORKS. 'Phone : 88781

ALFRED HERBERT LTD · COVENTRY

For Maximum Production



Fitted with 1½" Air Operated Automatic Chuck and Air Bar Feed

1¼" dia. Steel Bar, En.8. Made in pairs.

All Tungsten Carbide Cutting Tools

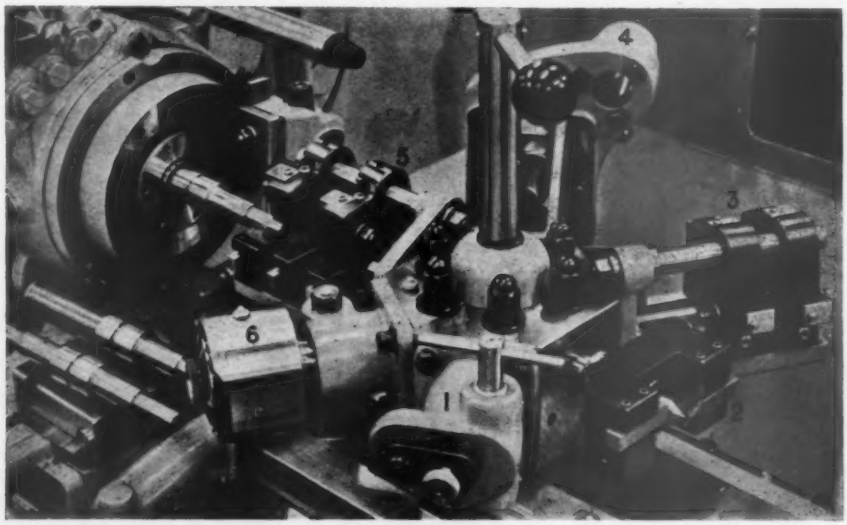
Ward

No. 2C CAPSTAN LATHE

RACK PINION SHAFT

DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
1. Feed to Stop, Chuck and Centre	1	—	—	—	Hand
2. Start Turn ⅝" dia.	2	—	1020	350	Hand
3. Multiple Roller Turn ⅝" and ⅞" dias.	3	—	1020	350	216
4. Knee Turn Gear Dia. 1¼"	4	—	2041	700	216
5. Face End B and Radius Shoulders A	5	—	2041	670	Hand
6. Double Radius Gear C	—	Front	2041	670	Hand
7. Feed out for Double Length	6	—	—	—	—
8. Support and Part-off D	6	Rear	2041	670	Hand
9. Re-chuck and repeat Operations 1, 2, 3, 4, 5					

Floor to Floor Time 2¾ minutes One End 4¾ minutes Complete



The standard No. 2C Capstan Lathe has a bar capacity of 1¼in. with a swing over the bed covers of 13¾in. Many new features are incorporated including inbuilt electrical equipment, twelve spindle speeds, both forward and reverse, raised centres giving an increased swing, large capacity swarf tray, bed protected by stainless steel covers, etc.

OUR COMPLETE RANGE INCLUDES CAPSTAN AND TURRET LATHES WITH CAPACITIES UP TO 35 in. SWING OVER BED AND 8½in. DIAM. HOLE THROUGH SPINDLE.

Full details on request

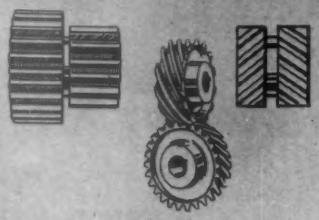
H.W. WARD & CO. LTD

SELLY OAK BIRMINGHAM 29

TELEPHONE SELLY OAK 1131

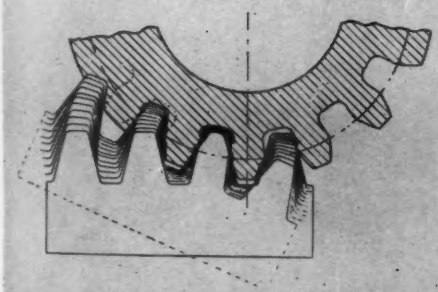
W 604

SUNDERLAND



FOR SPUR, SPIRAL & DOUBLE HELICAL GEARS

Photograph by Courtesy of
JOSEPH RHODES & SONS LTD, WAKEFIELD, YORKS.



THE 'SUNDERLAND' SYSTEM PROVIDES

- EXTREME SIMPLICITY AND MATHEMATICAL ACCURACY.
- RAPID OUTPUT AND EXCELLENT QUALITY.
- FEW CUTTERS AND GREAT RANGE AND CAPACITY.
- ONE CUTTER CUTS ANY NUMBER OF TEETH OF A PITCH.
- LOW INITIAL OUTLAY ON CUTTERS.
- LOW COST OF MAINTENANCE.

J PARKINSON & SON (SHIPLEY) LTD

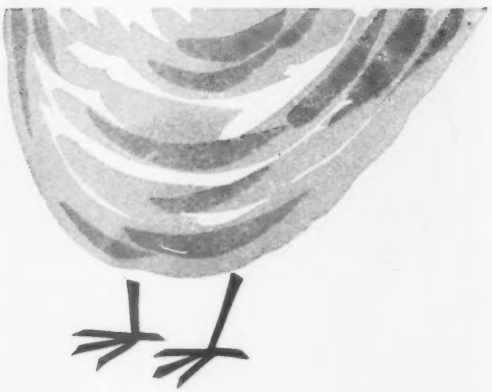
SHIPLEY YORKSHIRE

TELEPHONE 53231

P363B

HYDRAULIC
WITH
CONTOURING
LANG LATHES
LANG
LATHES
LAST LONGER
JOHN LANG & SONS LTD.
JOHNSTONE NEAR GLASGOW
Phone JOHNSTONE 400
L199A

If a hen and a half . . .



The use of precision electrically timed stud welding on the production line for Morley washing machines has improved their appearance and efficiency by elimination of eighteen unsightly fixing screws previously visible on the enamelled top.

We do not claim to understand anything about the intricacies of egg production, but we do have a very sound knowledge of the mathematics of industrial production lines.

For instance, we know that if a man and a half welds a stud and a half in a minute and a half, there is something very serious amiss. We could soon show how one man, using our stud welding system, could weld 30 studs in less time than it takes to soft boil an egg, let alone lay one.

If you're laying on a plan to speed up production, call in

THE STUD WELDING ORGANISATION

Crompton Parkinson LIMITED

ELECTRICAL EQUIPMENT

1-3 BRIXTON ROAD, LONDON, S.W.9. TELEPHONE: RELIANCE 7676

There's no escaping it– Wrought Iron is safer

All threats to human safety are not as clearly evident as this one. Many daily dangers are unseen and unsuspected—such as the possibility of failure by couplings, cable chains and cage and lifting gear. *Where equipment of this kind involves the lives of men and women, it is safer to specify Wrought Iron.*

Wrought Iron is very tough indeed. Its shock and strain resistance is outstanding. Its ability to withstand rust and corrosion is well known. And its inherent susceptibility to welding is intensified by slag inclusions. These qualities add up to an all-round, long-term superiority to mild steel for many purposes, in both safety and economy—especially where wet or outdoor conditions are concerned. At the Midland Iron Works we produce Wrought Iron in strips and bars, and in a variety of sections, for innumerable uses. We will gladly send you a free copy of our Section Book, and our technical representative is at your service for consultation on Wrought Iron application.

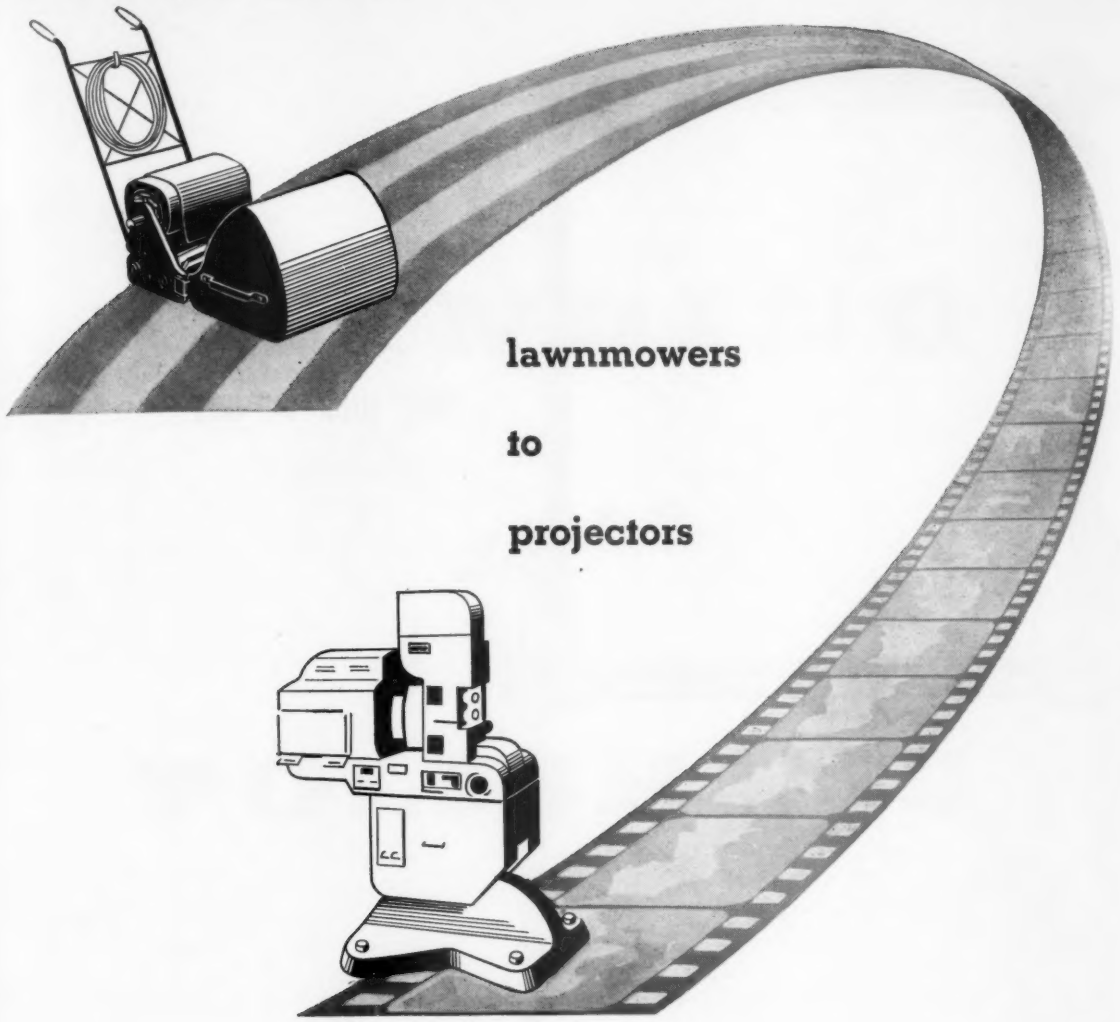
This nick-and-bend test piece clearly shows the fibrous structure of Wrought Iron, which gives it its high durability, shock-resistance and ability to absorb varying stresses and withstand severe vibrations. Wrought Iron is also distinguished by its ductility and exceptionally good machining properties.

The Midland Iron Co. Ltd

MIDLAND IRON WORKS · ROTHERHAM

...you can safely use Wrought Iron for a host of purposes

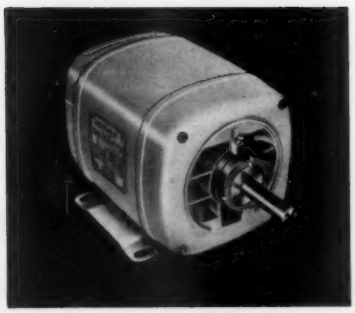
M18



lawnmowers

to

projectors



The uses of the Hoover F.H.P. Motor are almost endless. This sturdy, very dependable 'fractional' incorporates all the latest developments in motor design yet is still competitive in price. Remember, too, that all Hoover motors are backed by the unique Hoover service plan.

HOOVER LIMITED

Industrial Products Department
Cambuslang • Lanarkshire • Scotland

why pick on us?

Our way of producing the sections for this collapsible fire-escape ladder was by pressure die casting in aluminium alloy and if you can think of any quicker, cheaper and better way of doing it we'll go and jump off the roof of the nearest flaming building.

The patent fire-escape ladder is manufactured by BARKER MACHINE TOOLS & EQUIPMENT LIMITED of Amersham, Bucks.

CERTIFIED ZINC ALLOY ZAMCA DIE CASTERS

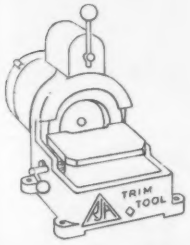
the whole in one

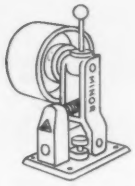
BRITISH DIE CASTING AND ENGINEERING COMPANY LTD.

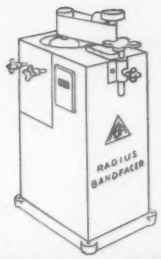
EDWARD ROAD · NEW BARNET · HERTS · TELEPHONE: BARNET 9211

Also at WEST CHIRTON TRADING ESTATE · NORTH SHIELDS · NORTHUMBERLAND · NORTH SHIELDS 2100

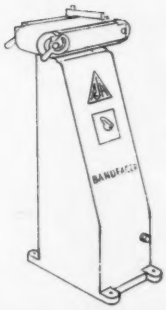
CRC 27



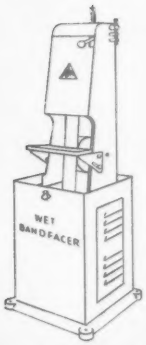




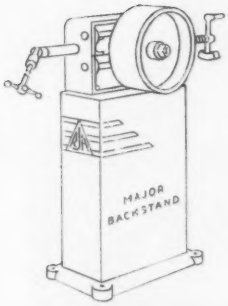
GRINDING



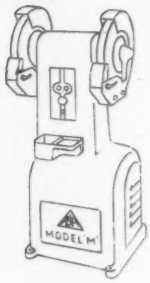
and

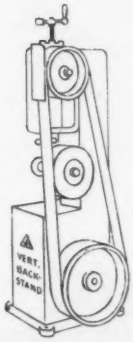


POLISHING

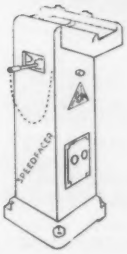


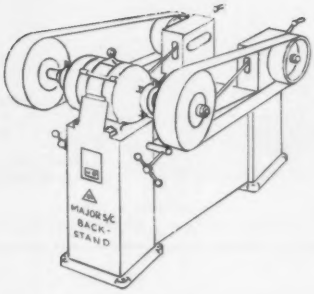
-better

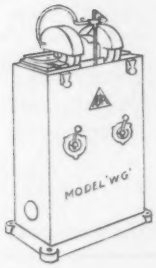




CONSULT RJH







THE R. J. H. TOOL & EQUIPMENT CO., LTD., HECKMONDWIKE, YORKS. Tel.: Heckmondwike 490
Makers of a wide range of Backstands, Bandfacers, Grinders, etc. *Send your enquiries to* ***R.J.H. the experts.***
r.j.h.

PG LTD

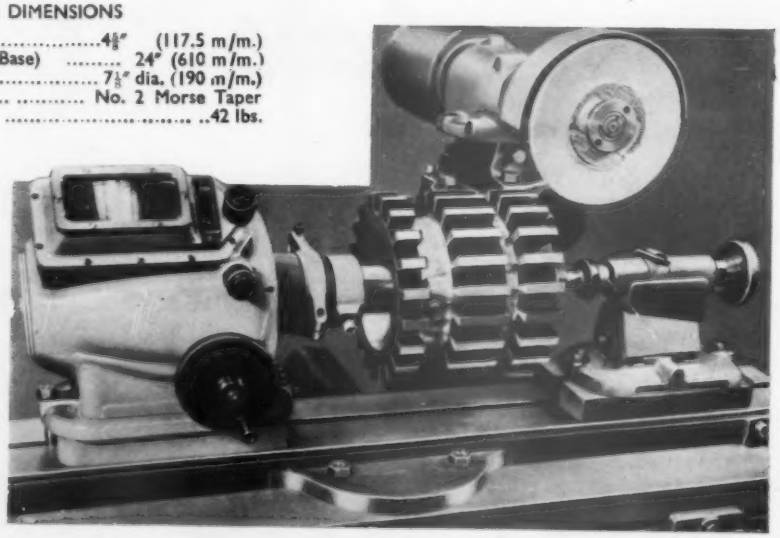
OPTICAL DIVIDING HEAD

COMBINES THE HIGHEST PRECISION WITH ROBUST CONSTRUCTION • MAG. UP TO 1,000X

Combining the following features: Dead centre, adjustable drive for zero settings, large vernier screen reading direct to 6 secs. (estimation 3 secs.) and conforms to N.P.L. Specification MOY/SCMI/56.

MAIN DIMENSIONS

Height of Centres	4½" (117.5 m/m.)
Centre Distance (on Base)	24" (610 m/m.)
Size of Face Plates	7⅛" dia. (190 m/m.)
Size of centres	No. 2 Morse Taper
WEIGHT OF HEAD	42 lbs.



PRECISION GRINDING, LTD.

MILL GREEN RD., MITCHAM, SURREY

'Phone : MITCHAM 3014

A SUBSIDIARY OF GEORGE H. ALEXANDER MACHINERY LTD. 82-84 COLESHILL ST., B'HAM. 'Phone ASTON CROSS 3264

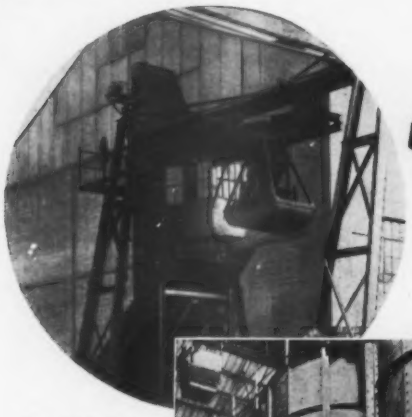
for high production repetition work

Archdale 24" PRODUCTION Millers

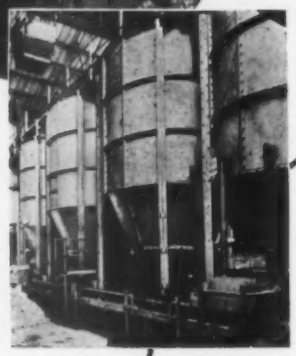
- AUTOMATIC CYCLES
- CLIMB OR PENDULUM MILLING

Especially designed for high production repetition work, this machine has a good record of performance at The Villiers Engineering Co. Ltd., Wolverhampton, where it is shown form milling gear box selector forks. Table cycles are fully automatic, ensuring the highest possible production on both climb and pendulum milling. Traverse can be extended to suit special requirements.

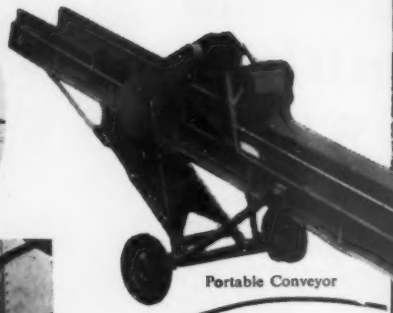
JAMES ARCHDALE & CO. LTD. BIRMINGHAM 15 · SOLE SELLING AGENTS: ALFRED HERBERT LTD. COVENTRY



Complete Telpher Installations



Sand Storage Hoppers



Portable Conveyor

Pallet Conveyors

Something worth knowing

Paterson Hughes Mechanical Handling Systems are used in almost every industry in the world.

Portable Sack Elevator

Roller Conveyor Systems

Slat Conveyors

Overhead Travelling Cranes

Sand Conditioning Plant

Overhead Chain Conveyors

PATERSON HUGHES
ENGINEERING COMPANY LIMITED

LONDON · BEDFORD HOUSE, BEDFORD ST., STRAND, LONDON, W.C.2 Phone TEMPLE BAR 7274-6
BIRMINGHAM · 3 HIGHFIELD ROAD, EDGBASTON, BIRMINGHAM 15 · Phone EDGBASTON 2957-8
GLASGOW · WYNDFORD WORKS, MARYHILL, GLASGOW · Phone MARYHILL 2172-4
SOUTH AFRICA · PATERSON HUGHES ENGINEERING S.A. (Pty) Ltd., P.O. Box 811 JOHANNESBURG, S.A

MECHANICAL HANDLING ENGINEERS AND CRANE MAKERS

"GIVE THEM THE WORKS"
said the chairman

Advertising men get coy when you ask them to put a nice big picture of the works in the ads. "Works and Whiskers," they cry, "Never, its your products readers want to see."

Against their advice we are giving you the works—or one of them, for we have three. Why? Because many of our customers have never visited them, have no idea of their size or scope. We are the largest zinc and aluminium alloy pressure die-casting concern in Europe— yet another reason why your work will be well looked after if you pass it over to us.

The Chairman's Whiskers ?

Sorry, he's too modest.

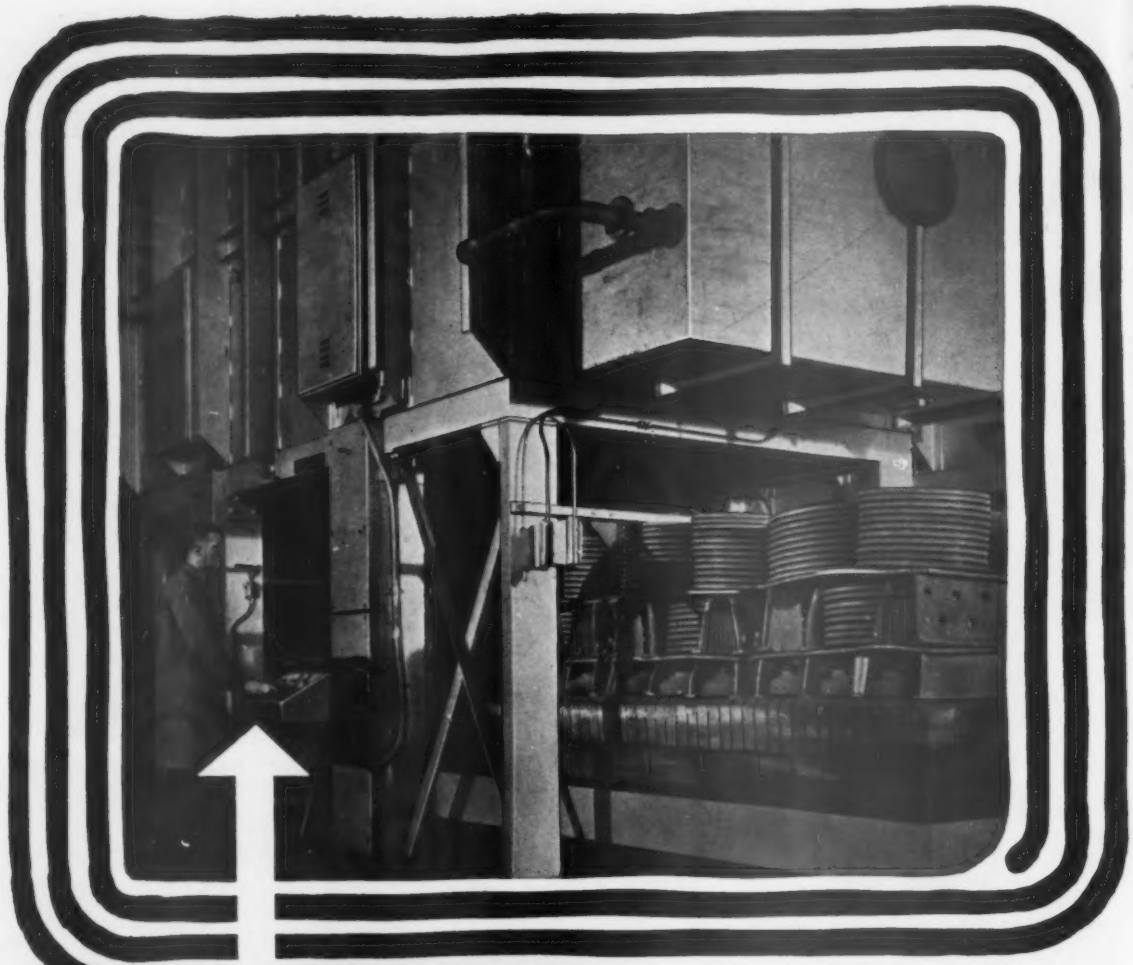
P.S. If *you* would like to see our works let us know.

CERTIFIED ZINC ALLOY ZAMCA DIE CASTERS

30 YEARS' ANGLO-AMERICAN DIE-CASTING EXPERIENCE

WOLVERHAMPTON DIE-CASTING
AFFILIATED WITH
PRECISION CASTINGS CO. INC. (U.S.A.)

WOLVERHAMPTON DIE-CASTING CO. LTD., GRAISELEY HILL WORKS, WOLVERHAMPTON Tel.: 23831-6



Load charge!

The finger on the button, a slight movement — and into the furnace go five or more tons of castings. Like all iron castings they go in brittle, but after a cycle of heat, soak and slow cool in the controlled atmosphere, they come out malleable. Gaseous annealing in an electric furnace is quick and efficient — whereas conventional methods, involving packing in boxes, require much fuel, labour and materials. For consistent high quality in the product, for cleanliness in the works, and for low costs in the process, there is nothing like an electric annealing furnace — but it is

only one of the many aids to higher productivity that Electricity can bring you.

Having a hand in Productivity

In every industry or trade, electrical equipment is the key to modern production methods. There are probably more production-boosting and money-saving devices than you know of. Your Electricity Board can help you and give you sound advice.

They can also make available to you, on free loan, several films on the uses of electricity in Industry — produced by the Electrical Development Association.

E.D.A. are publishing a series of books on " Electricity and Productivity ". Four titles are available at the moment; they deal with Higher Production, Lighting, Materials Handling, and Resistance Heating. The books are 8/6 each (9/- post free) and the Electricity Boards (or E.D.A. themselves) can supply you.

The British Electrical Development Association
2 Savoy Hill, London, W.C.2.

Electricity a Power of Good for PRODUCTIVITY

there's no gamble on these cards

. . . they represent the efficient, nation-wide service maintained by Spencer and Halstead Ltd., to ensure that all plant of their manufacture receives speedy and expert attention in the event of a break-down. These fully trained representatives will gladly advise any user, or potential user, of Spenstead equipment, how to get the best service from his plant.

SPENCER & HALSTEAD LTD

BRIDGE WORKS, OSSETT, YORKSHIRE. TEL: OSSETT 353/4. GRAMS: SPENSTEAD, OSSETT.

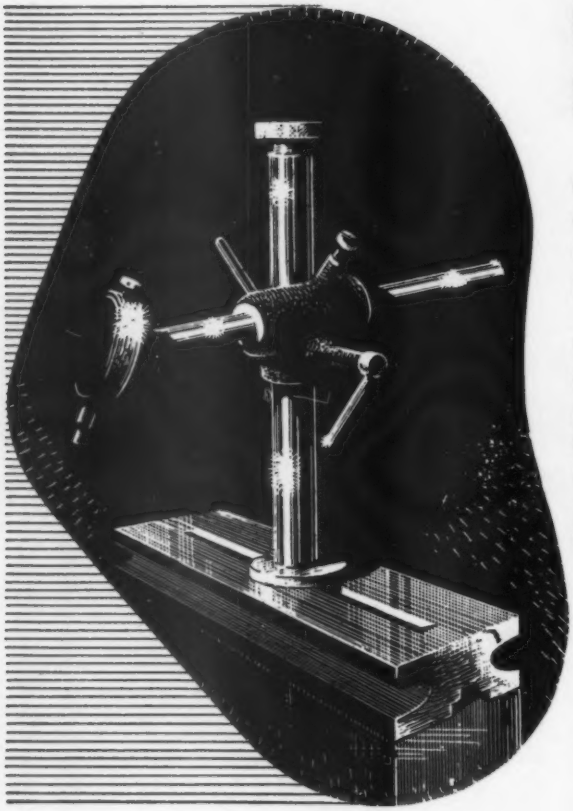
Manufacturers of Fans, Dust Collection and Ventilating Plant, Shot Blast Plant.

P.4569

We welcome your enquiries

FOR ALL KINDS OF

JIGS · FIXTURES & GAUGES



PRESS TOOLS · MOULDS AND SPECIAL PURPOSE MACHINES

Our commitments are heavy but we welcome an opportunity to study your requirements for inclusion in our production programme where possible.

Up-to-date shops specially laid out and equipped for making, on a production basis, every type of precision ground gauges; limit snap, form, calliper, taper and special purpose gauge, as well as jigs and fixtures of all kinds, press tools moulds and special purpose machines. Highest class workmanship and accuracy guaranteed.

Guaranteed
Precision
Accuracy

G.P.A.

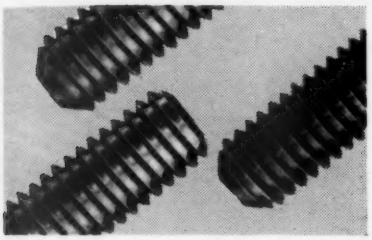
G.P.A. TOOLS & GAUGES LIMITED

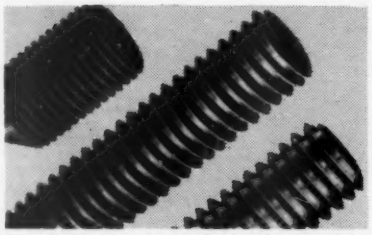
HARPER ROAD · WYTHENSHAWE · MANCHESTER

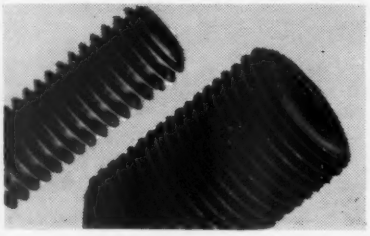
Phone:- **WYTHENSHAWE 2215**

'Grams:- **PNEUTOOLS, PHONE**

Why Unbrako?







To speed production? Look for easy thread start, the hex socket for speedy, sure drive.

For staying power? Unbrako closer tolerances mean a better fit, and their tremendous toughness allows the screws to be pulled up tighter, to stay put longer without locking. Unbrako vibration tests prove this.

For dependability? The reputation of the best equipped specialist screw organisation in Europe stands behind every single Unbrako production, so they've got to be good. They are obtainable all over the world.

UNBRAKO SCREWS COST LESS THAN TROUBLE

UNBRAKO

UNBRAKO SOCKET SCREW CO., LTD., COVENTRY

TOWN

RADIAL DRILLING MACHINES

Rigid, simple design, conveniently placed controls and maximum rates of production on the widest range of components —a few of the reasons why they are called upon to give service all over the world.

Illustrated: Town 5ft. A.E.4 Radial Drilling, Boring, Tapping and Studding Machine Drilling capacity from solid 2½in. diameter in steel and 3in. diameter in cast iron. Tapping 1¼in. Whitworth.

FREDERICK TOWN & SONS LTD

HALIFAX · YORKS

COSSOR presents Model 1052 double beam oscillograph

Two similar amplifier channels with an approximate gain of 2000 and an upper frequency response of 5 megacycles (– 6DB) are features of this new Cossor Double Beam general purpose oscillograph. The repetitive or triggered time base has a sweep duration from 200 milliseconds to 5 microseconds.

The instrument will operate from power supplies of any of the various frequencies and voltages encountered in the Armed Services or from standard civil supply mains.

Full scale production of this instrument now enables us to announce a reduction in price.

and Model 1433 voltage calibrator

Primarily designed to be used with the Model 1052 oscillograph the Cossor Voltage Calibrator Model 1433 provides an accurate means of calibration of input voltages to the plates or amplifiers of any oscillograph. Calibrating voltages are read directly from a wide scale meter without any computation being necessary. Measurements can be made to an accuracy of ± 5% and the instrument can be used in any application where a source of accurately-known voltage is required.

COSSOR ELECTRONIC INSTRUMENTS

Write for illustrated leaflets about both of these instruments

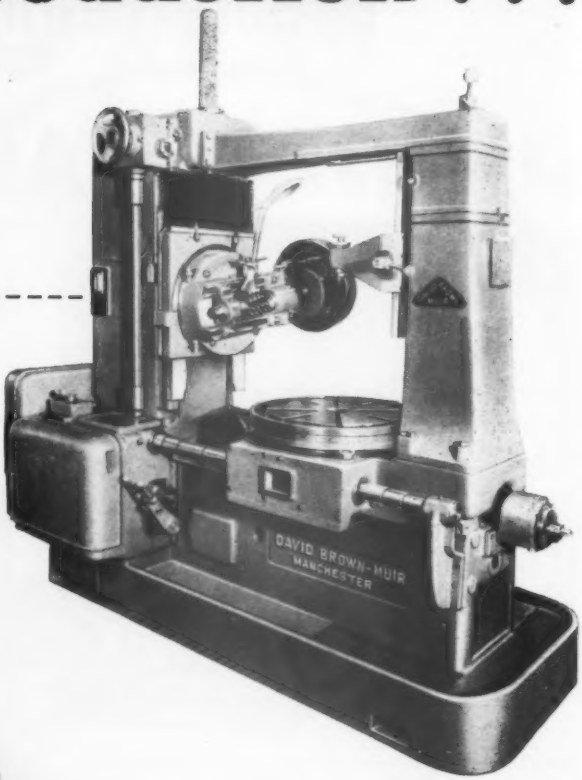
Watch out for the new
TELE-CHECK AND CRYSTAL MONITORED MARKER GENERATOR for Bands 1 & 3

A. C. COSSOR LTD., INSTRUMENT DIVISION, DEPT. 35, HIGHBURY GROVE, N.5
Telephone: CANonbury 1234 (33 lines). Telegrams: Cossor, Norphone, London. Cables: Cossor, London

C.I.56

ALWAYS USE COSSOR TUBES & VALVES

MT 15 MT 30 Gear Production . . .



The test of any hobbing machine is, will it increase production, cut costs and give increased accuracy. These requirements are met by David Brown-Muir machines, and the standard MT15 and MT30 models, of 15 and 30 inches gear capacity respectively, are particularly attractive for the production of a wide variety of spur and helical gears, splines and serrations.

In addition, the universal machines will generate worm wheels by the tangential feed methods.

Write for illustrated brochures M.100.8 and M.100.11.

THE

DAVID BROWN

CORPORATION (SALES) LIMITED

MACHINE TOOL DIVISION

BRITANNIA WORKS SHERBORNE STREET

MANCHESTER 3

ever punched a **FACT?**

For production control, the accumulation and co-ordination of detailed data about materials and processing demands speed, accuracy. Do it by punching. There is no faster or better means of compiling and presenting information than that afforded by the Powers-Samas Punched Card System. Ask for more information from—

POWERS-SAMAS

Powers-Samas Accounting Machines (Sales) Ltd., Powers-Samas House, Holborn Bars, E.C.1.

When replying to advertisements please mention the Journal

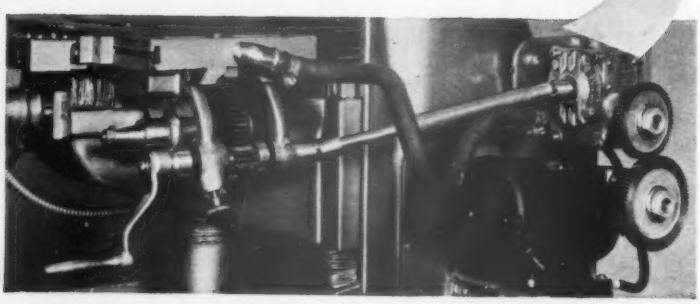
CUTTING AND TOOL GRINDING MACHINE

The G.F.3 was introduced originally to satisfy the demand for a small universal machine suitable for use with Neven Diamond Impregnated Tools for chipbreaker grinding and similar tool room work, and certain production operations.

The Mark II model has been developed on the same lines as the original Mark I, but with many improvements, and also a far higher degree of precision. As a result of numerous requests we have now added to our range the Mark IIa model with an automatic traverse; this retains the original simplicity of the Mark II with the addition of a sturdy and compact traversing unit.

G.F.3 MARK II

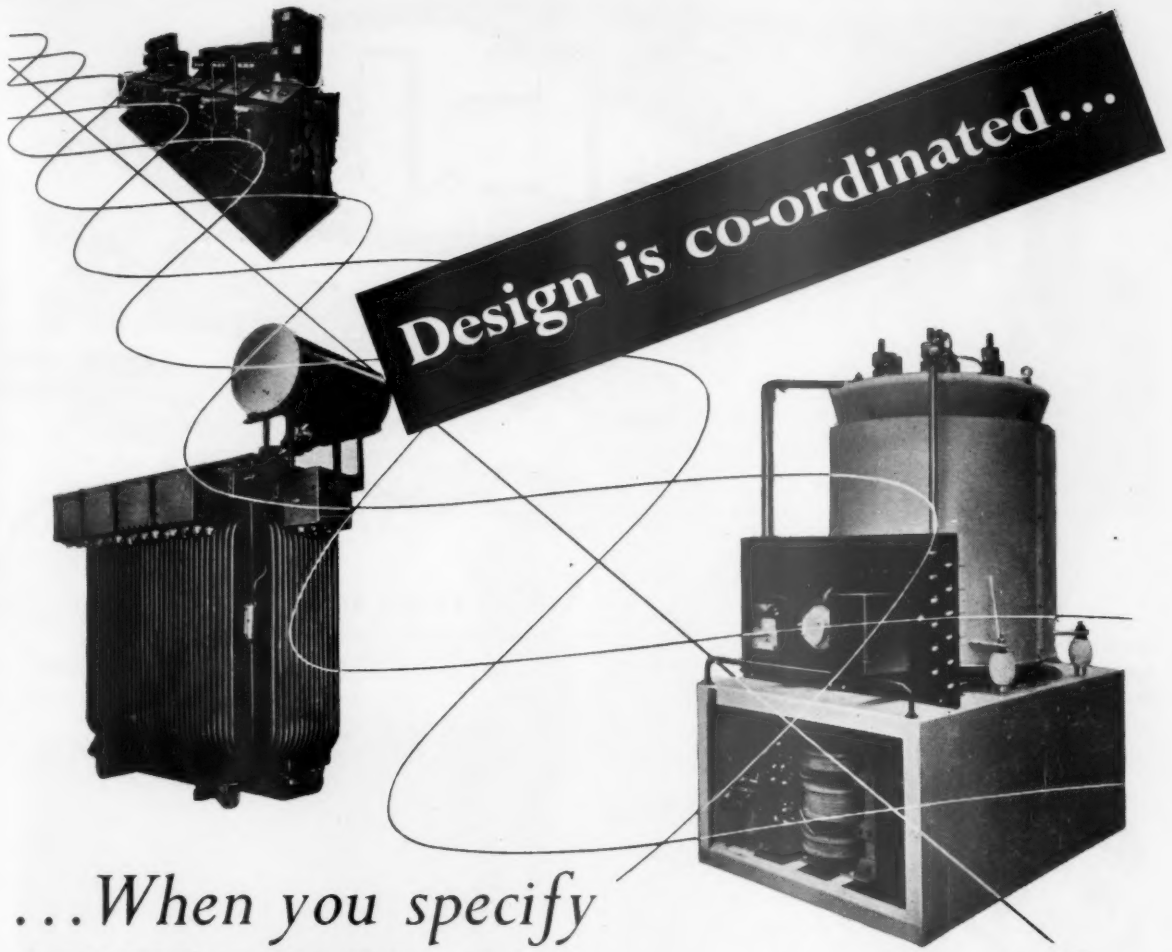
G.F.3 MARK IIa with automatic traverse



Close-up of assembly with cover removed

IMPREGNATED DIAMOND PRODUCTS LTD. - GLOUCESTER ENGLAND

TELEPHONE 21164 (3 LINES) TELEGRAMS IMPREG GLOUCESTER



...When you specify METROVICK Mercury-Arc Rectifiers

Metropolitan-Vickers produce a wide range of glass bulb, pumpless steel tank and continuously evacuated steel tank mercury-arc rectifiers. Further, the company's service covers a complete installation including rectifiers, transformers, switchgear and all auxiliary equipment. In this way design is co-ordinated throughout and full advantage taken of the breadth of Metrovick experience over the whole field of power supply. Any service requiring D.C. power, from general industrial applications to tram, trolleybus and heavy traction requirements, can be met from the Metrovick series of rectifiers. Write for full technical details.

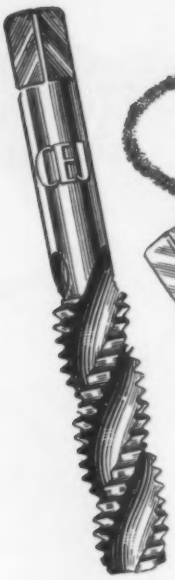
Metrovick 3,000 amp pumpless steel tank rectifier equipment showing one rectifier withdrawn on its carriage.

METROPOLITAN-VICKERS
ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER 17

CR 203

Members of the A.E.I. group of companies.

CEJ



CEJ TAPS

Spiral Flute Taps for blind hole tapping.
Spiral Point Taps for through hole tapping.
In each case only one tap is needed.

CEJ PLUG & RING GAUGES

are in steadily increasing demand throughout industry. Their precision and exemplary accuracy ensure complete satisfaction.

CEJ ROUND DIES

Adjustable or solid; obtainable in all standards.

CEJ GAUGE BLOCKS

are the foundation for accuracy and precision in the Engineering Industry and are universally adopted by industrial and scientific users.

They are manufactured to four Standards of accuracy:-

Accuracy AA for highest scientific purpose.
Accuracy A for reference use.
Accuracy B for inspection use.
Accuracy C for workshop use.

C.E. JOHANSSON LTD.

PRECISION TOOLS AND INSTRUMENTS

A.I.D. & A.P.I. APPROVED

SOUTHFIELDS ROAD · DUNSTABLE BEDS · TEL: DUNSTABLE 422/3

DHBK.

continuous COPPER BRAZING FURNACES with REMOVABLE elements

Birlec Limited can now offer continuous copper brazing furnaces with removable non-metallic elements as standard equipment. Extensive production trials have taken place and the following advantages proved:—

- ★ ***Element replacement is easy and can take place, if necessary, while the furnace is in operation.***
- ★ ***Element replacement does not involve rebricking, and expensive downtime is thus reduced.***
- ★ ***Element life is no shorter than with conventional nickel-chromium resistors.***

...also INDUCTION HEATING

For brazing a small part to a large article, induction heating equipment is the answer; localised heat means no wasted heat and a "machine tool" approach to equipment design makes the process ideal for quantity-production methods.

Illustration left: A standard 5kW unit, for brazing carbide tool tips; Photograph by courtesy of EDIBRAC LTD., Broadheath, Cheshire, manufacturers of Tungsten Carbide products.

Designs are completed for standard 6", 8" and 12" furnaces; may we send details? We should also be pleased to arrange a visit to our Heat Treatment Division, near the main works in Tyburn Road, where test pieces can be brazed in a furnace of this type.

BIRLEC LIMITED

ERDINGTON · BIRMINGHAM · 24

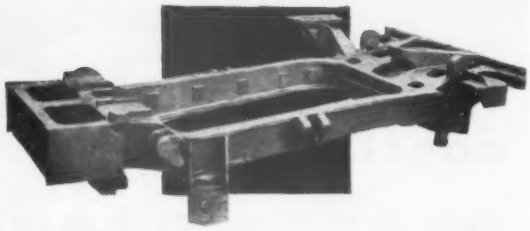
BIRLEC

Sales and service offices in **LONDON · SHEFFIELD · GLASGOW · NEWCASTLE-ON-TYNE**

SM/B.2134.54

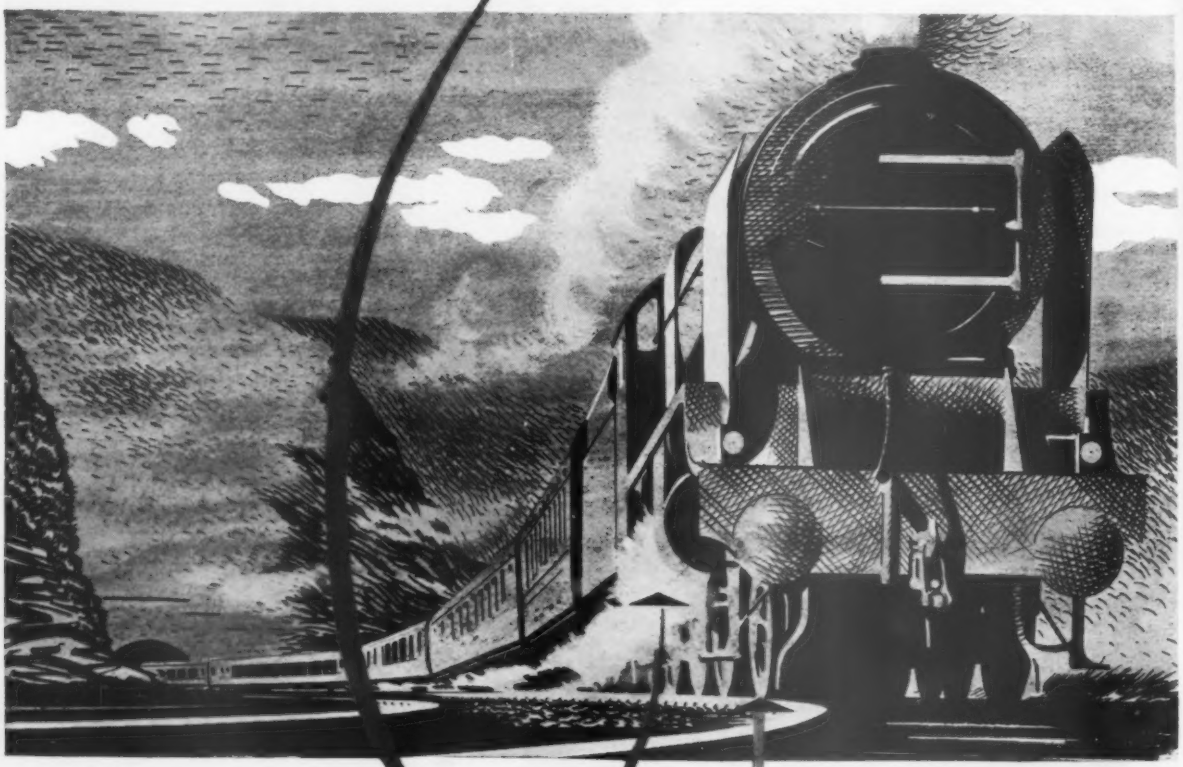
(Member of the A.E.I. Group of Companies)

Cast for an important part . . .



Consider the strength of a Railway engine

Few machines have to be made to such rigid standards of strength and soundness as railway rolling stock. It is because of the need for calculated, unfailing strength in the component parts that Lloyds, with their unsurpassed facilities for scrupulous control at every stage of production, are called upon by Britain's leading locomotive and railway engineers to supply steel castings for their products. Castings made by Lloyds for the Railway industry include wheel centres (bottom right), loco frame cradles (above), bogie bolsters and axle boxes. *Send for a copy of Lloyds Craftsmen in Steel. Post free.*



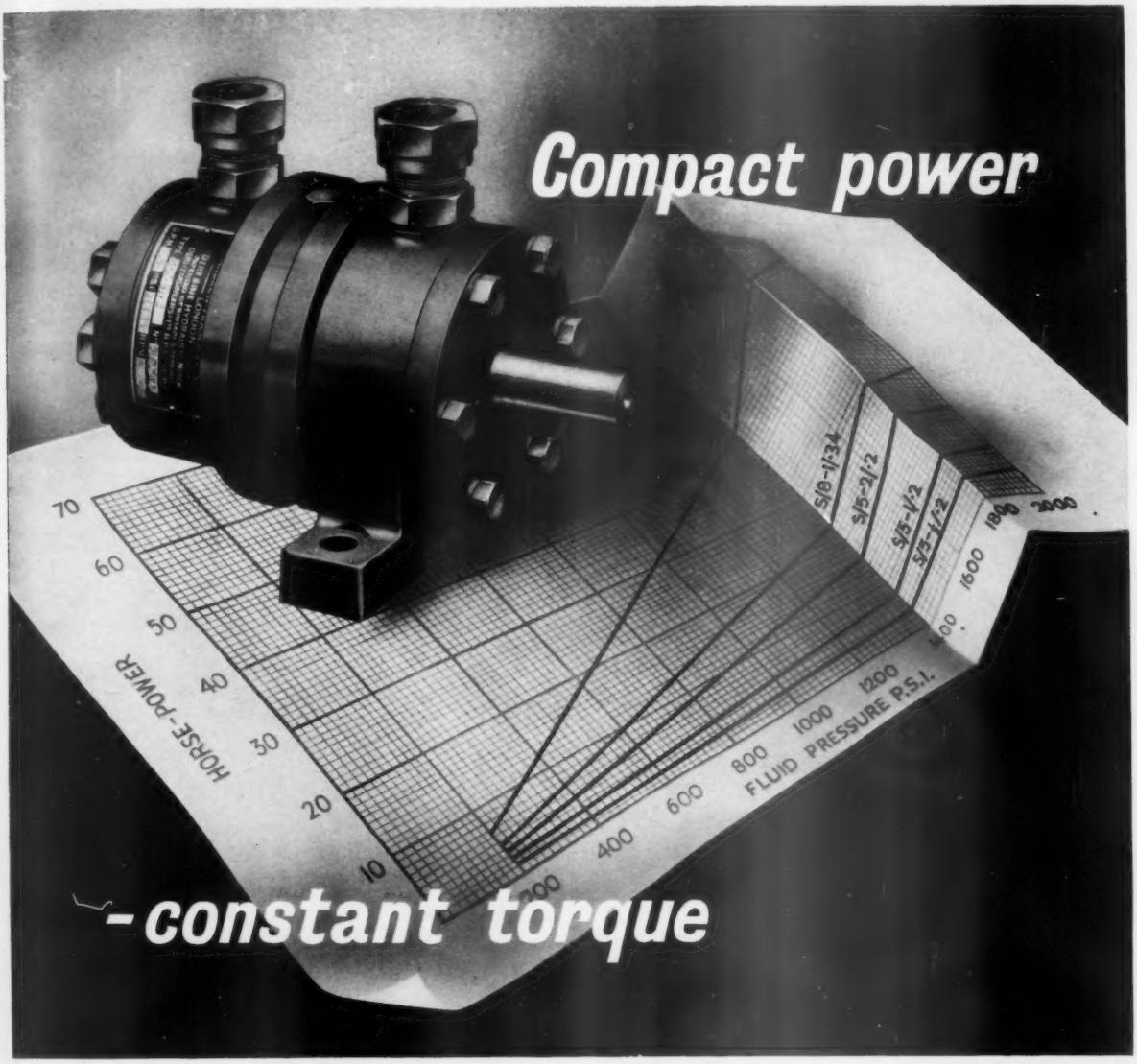
Cast and machined by

LLOYDS

Britain's Best Equipped Steel Foundry

F. H. LLOYD & CO. LTD., P.O. BOX 5 · JAMES BRIDGE STEEL WORKS · WEDNESBURY · STAFFS · PHONE: DARLASTON 225

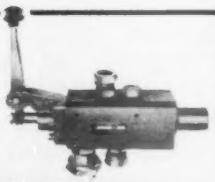
A Print for Industry Ltd. Advertisement



Constant and full load starting torque is only one of the features of this outstanding hydraulic motor. It introduces high efficiency at low speeds and maintains it throughout the range, and provides exceptionally smooth transmission of power for a widely varied number of applications. Capable of rotation in both directions.

The smooth and vibrationless operation of the Motor is also a feature of the Deri-Sine Hydraulic Pump, a rotary displacement pump of high volumetric efficiency, which is essential to the power circuit.

An output of up to 4,000 lb./in. torque is available in a range of four basic sizes which incorporate variations in stator and rotor dimensions.



VALVES.—Mono-Radial Control Valves—built with precision and virtually foolproof—are arranged for one or more hydraulic supplies under manual, remote, or power operation.

for efficiency fit a FRASER DERI-SINE Hydraulic Motor

ANDREW FRASER & CO LTD 29 BUCKINGHAM GATE LONDON SW1 PHONE VICTORIA 6736-9

P778

"I told him straight! . . ."

said the Factory Manager

"*I told the Guv'nor straight*," he said, "*— if you want this lot out on time, I want more up-to-date handling equipment!*"

We murmured admiration for his fearlessness . . . then we told him we were from Yale & Towne; we'd been called in by "the Guv'nor" to see how we could help.

"*Well, you can see for yourself the trouble*," he said, with a sweep of his hand. "*Hold-ups here — hold-ups there. We just can't keep the stuff moving.*"

We checked everything that was moved in, around and out of the factory. Our recommendations went to the Board.

A couple of months later we were back at the factory watching the early runs with the new equipment. Everyone was enthusiastic about the way things were going. They had every reason to be: production hold-ups had become a thing of the past.

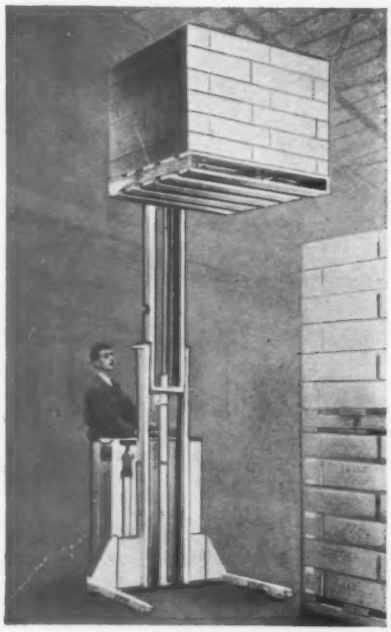
"*The way the Guv'nor's beaming, you'd think it was all his idea*," said the Factory Manager.

Why not pass your handling problems to us? Our Technical Representatives will call and advise you how Yale can solve your materials handling problems and help reduce production costs.

Here's a *new* answer to your "no-space" problem!

The new "Warehouser" range is the latest and most advanced driver-operated series of trucks now available . . . compact, more manœuvrable, fast and safe! The "Warehousers" give you all these outstanding advantages:—

- ★ Rounded rear end for right angle stacking in 5 and 6 foot aisles.
- ★ Lightweight for low floor loadings.
- ★ One hand operation for hoist, lower and drive.
- ★ "Dead man" control — applies brakes, cuts power.
- ★ Safe and easy driving position.
- ★ Fast handling speeds.
- ★ Straddle fork lift models available in 2,000 and 3,000 lbs. capacities, with standard lifts to 147". Pallet and low lift platform models up to 2 tons capacity.
- ★ Available with either lead-acid or nickel-alkaline batteries.
- ★ Low initial cost, low running cost, economical up-keep, long life.



The "Warehouser" Fork-Lift Straddle Truck.

MATERIALS HANDLING EQUIPMENT

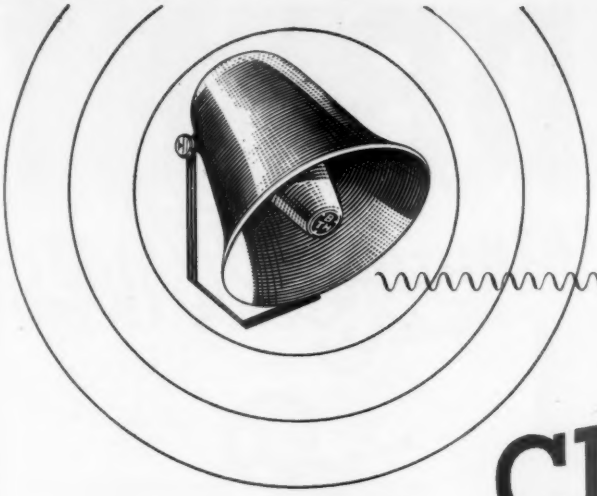
MADE IN ENGLAND BY

YALE

REGISTERED TRADE MARK

THE YALE & TOWNE MANUFACTURING COMPANY

MATERIALS HANDLING DIVISION (DEPT. U3) · WEDNESFIELD · STAFFS · PHONE WILLENHALL 630



CLEAR AS A BELL

CLEARCALL

Industrial Communication System

With "Clearcall", speech can be clearly heard through the din of a noisy factory, or it can be adjusted for quiet surroundings.

"Clearcall" components are of rugged industrial design, and will not fail in spite of dirt, damp, and rough usage.

The equipment is suitable for iron and steel works, rolling mills, etc., paint and varnish factories, chemical works.

SAFE!

"Clearcall" components are the subject of an "intrinsic safety certificate" in respect of Pentane Vapour etc. Details on application.

THE
BRITISH THOMSON-HOUSTON
COMPANY LIMITED, RUGBY, ENGLAND

B T-H

A4582

Member of the AEI group of companies

BROADBENT *Lathes*

THE BROADBENT Range of Types "M½" and "L" Sliding, Surfacing and Screwcutting Gap-bed Lathes 8½" to 18" centre heights, reflect in their design and performance the accumulated knowledge and experience gained during 80 year's Machine Tool manufacture and development.

Write for descriptive literature on the full range of BROADBENT LATHES

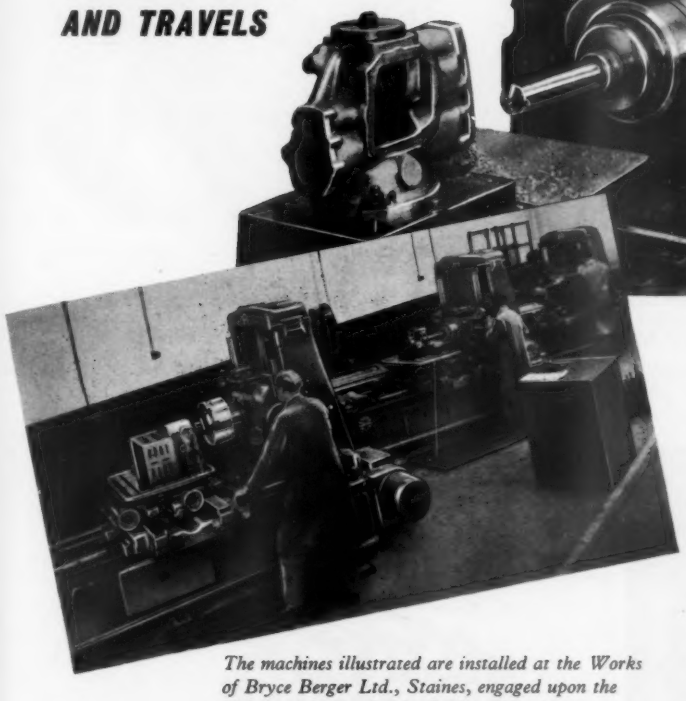
BROADBENT

HENRY BROADBENT LIMITED

SOWERBY BRIDGE, YORKS Telephone : Halifax 81331

DIXI '60' SWISS BUILT

HORIZONTAL PRECISION BORER



- ***EXCEPTIONAL ACCURACY***
- ***HIGH DEGREE OF FINISH***
- ***INFINITELY VARIABLE SPINDLE SPEED AND TRAVELS***

The machines illustrated are installed at the Works of Bryce Berger Ltd., Staines, engaged upon the high precision production boring of intricate castings and forgings used for high priority work.

Design Features include:

All scales and dials clearly marked and equipped with optical microscopes for extremely fine settings.

Slide-ways hydraulically actuated.

Optical Precision Circular Dividing Table available, reading in seconds of a degree.

Facing and milling operations also handled.

Boring feeds from table slide if necessary, thus avoiding spindle deflection.

Send for detailed catalogue

SOLE U.K. DISTRIBUTORS

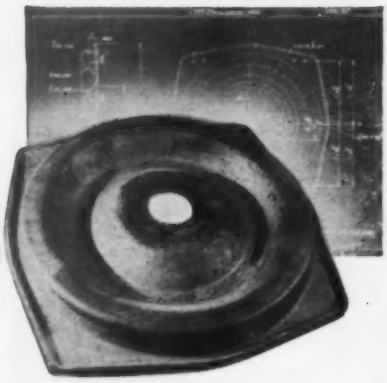
DOWDING & DOLL LTD

346 KENSINGTON HIGH STREET, LONDON, W. 14

Telephone: WESTERN 8077 (8 lines) *Telegrams*: ACCURATOOL HAMMER LONDON

6o

Pressing –A MODERN MANUFACTURING SCIENCE

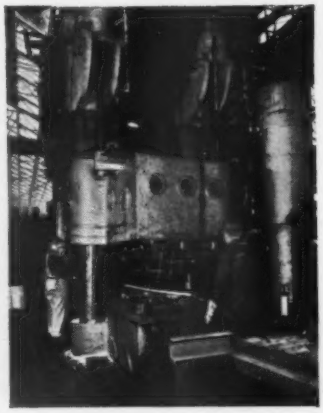


Strength
Weight
Shape

Skilled manipulation of flat steel sheet in modern power presses by means of expertly contrived dies is a process of manufacture which holds out enormous possibilities to the Designer and to the Production Engineer.

A steel pressing has a remarkably high strength to weight ratio; it can be die-formed to the required shape by one or a short series of pressing operations, with very close dimensional accuracy; and large or small numbers of parts can be produced economically, often at a cost lower than would be practicable by any other process of manufacture.

We are shortly to publish a series of leaflets illustrating pressings in current production as an indication of our capacity and of the facilities that this particular manufacturing process provides; *copies will be sent to all interested Engineers and Designers who will let us know that they would like their names to be included on our mailing list for these leaflets.*



This 2000 ton mechanical press can produce cold pressings up to 25 feet in length and between $\frac{1}{32}$" and $\frac{1}{4}$" thick according to the area of the component. The press is fitted with hydro-pneumatic die cushions. Here it is producing half sections for chassis side box members, two at a time.

Please address enquiries to:

JOHN THOMPSON MOTOR PRESSINGS LIMITED · JOHN THOMPSON GROUP

JOHN THOMPSON
MOTOR PRESSINGS LIMITED
WOLVERHAMPTON

If it's *BORING...*

(*turning, milling or grinding*)

'Finish' it quickly and well with one of the

STERNOL SOLUBLE Straight Cutting Oils.

Economical and stable under all conditions, they can be used on any metal.

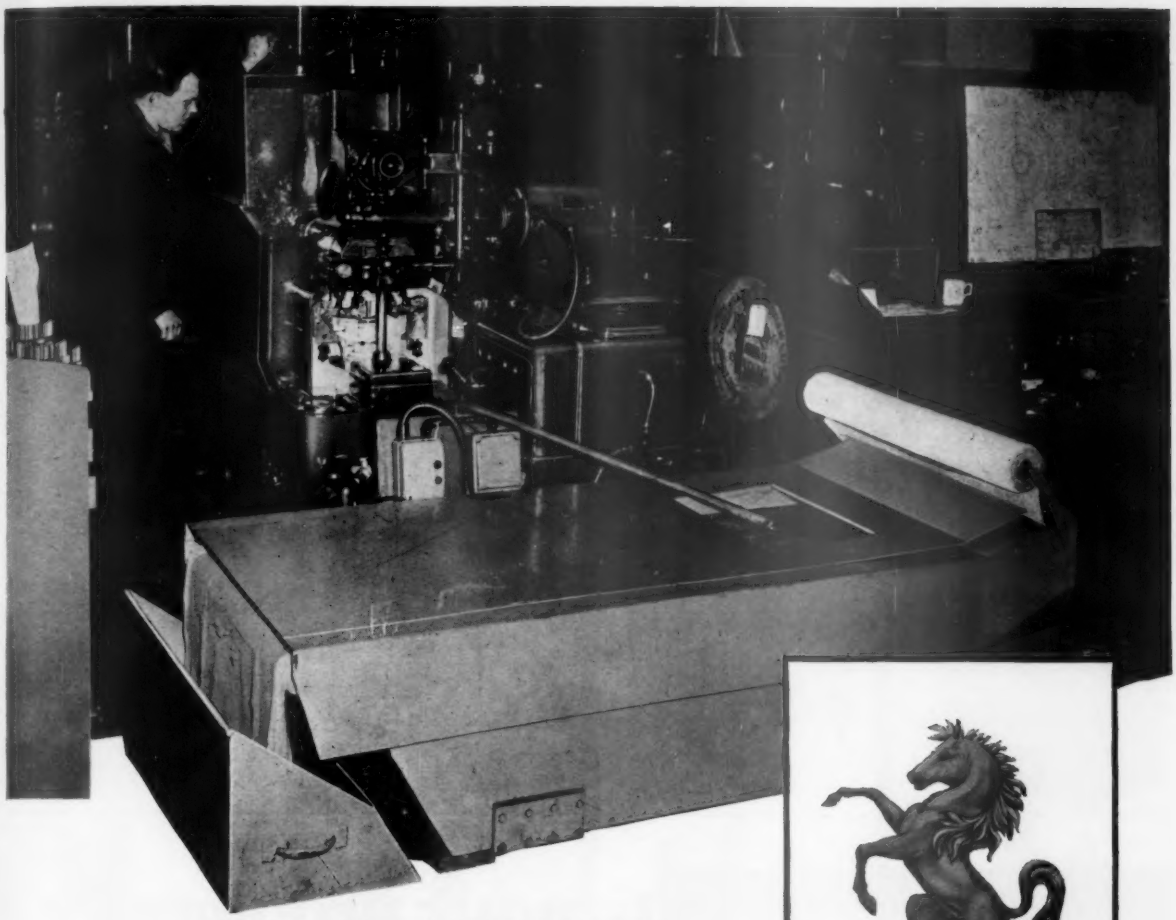
Write for Sternol booklet SS. 638 giving the appropriate oil for every operation.

You need

Sternol

STERNOL LIMITED

ROYAL LONDON HOUSE, FINSBURY SQUARE, LONDON, E.C.2



Reproduced by courtesy of Aveling-Barford Limited.

Messrs. Aveling-Barford of Grantham, the originators and world's largest manufacturers of road rollers were the first 'Filtrall' users to employ a unit for filtration of neat cutting oil in their gear grinding section.

The installation has resulted in improved production time—increased output—longer grinding wheel life—superior component finish and considerable economy in the use of cutting oil.

Our Filter Sales Division will be pleased to advise you on your filtration problems and will arrange for a trial of a suitable unit in your works without obligation.

FILTRALL

INDUSTRIAL FILTERS

Filtrall Industrial Filters. Standard models in capacities from 600 to 1,800 gallons per hour. Larger installations built to customers requirements.

For perfect filtration of:-

Coolants - Quenching oils - Run-in oils Paper Pulp - Edible oils - Soyabean solutions - Syrups - Parts Washing solvents - Drawing oils - Spray Booth water etc.

Please address enquiries to—

NEWALL GROUP SALES LIMITED

PETERBOROUGH · Phone Peterborough 3227-8-9

SALES ORGANISATION OF THE NEWALL GROUP OF COMPANIES

P747

THE "HYDETSCO" (British) HYDRAULIC SHAPING AND PLANING Machines

Illustration shows the 24 in. stroke SHAPER.

Variable speeds, instantly controlled and quick return.

Extremely heavy cuts can be made if needed and without risk of breakages to Machine.

36 and 72 in. stroke Machines made as open sided PLANERS.

Full details from: **C. H. JOYCE Ltd.** 40, MONKTON STREET, (Kennington) LONDON, S.E.11.

PHONE: RELiance 1437 (3 lines)

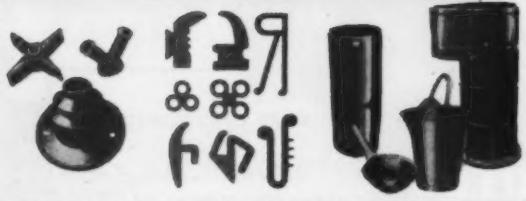
What's your problem?

Insulation? Protection? Silencing? Sealing?

Simple or complex, Redfern's will help to solve it. We have the experience, capacity and resources for economical bulk production of moulded components and extruded sections in natural and synthetic rubbers, and ebonite. Plan with all the knowledge of our technical staff at your elbow — we are always pleased to advise on the use of these versatile materials, and translate designers' ideas into terms of efficient production. Send us your enquiries—we will do the rest!

Literature is available describing our service — MOULDINGS . . . EXTRUDINGS . . . anti-corrosive LININGS & COVERINGS . . . FLOW FITTINGS (piping, cocks, tees, etc.,) . . . chemical-resisting UTENSILS . . . FABRICATED PARTS to specification.

A request to add your name to our mailing list will keep you up-to-date with publications dealing with any of these items.



MOULDINGS — EXTRUDINGS — FABRICATED PARTS AND UTENSILS

REDFERN

RUBBER & EBONITE

WILL HELP YOU SOLVE IT!

REDFERN'S RUBBER WORKS LTD · HYDE · CHESHIRE

T.P.313

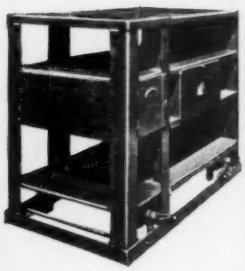
four ways of finding things

There's no difficulty in keeping tools close to hand when you install "Steelpact" Tool-Stands. Manufactured from heavy gauge sheet steel, these sturdy units are available as plain stands with three trays or three trays and a steel locker.

TYPE 161 TOOL STAND

In Assembly Shops where maximum storage accommodation is required, "Steelpact" Work Benches are the ideal solution. Available in permanent and mobile forms, they provide that rigid work surface and ample storage space essential for efficient production.

TYPE 111 WORK BENCH



Safely locked away yet always visible, the contents of this "Steelpact" Locker can be checked at a glance without opening the door. The door and two sides are fitted with woven wire mesh, the top, back and bottom being of solid sheet steel.

TYPE 170 TOOL LOCKER

Lost tools mean lost time, but here's a way to keep them within easy reach yet well out of harm's way. "Steelpact" totally enclosed Tool Lockers are constructed of heavy sheet steel, each locker being provided with two shelves, single door and dished top to form a tray. Two sizes are available.

TYPE 172 TOOL LOCKER

STEELPACT

WORKSHOP FURNITURE

FAWCETT PRESTON

furnishers to production

FAWCETT PRESTON & CO LTD BROMBOROUGH CHESHIRE

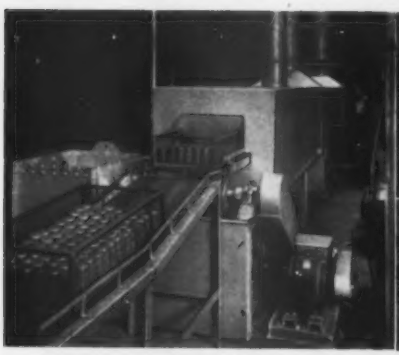
Write for illustrated brochure describing:— Permanent, Semi-Portable and Mobile Work Benches, Tool Stands and Lockers. Inquiries also invited for Foremen's Desks and Testing Benches, Erection Trestles and other special or non-standard workshop furniture

ONE OF THE METAL INDUSTRIES GROUP OF COMPANIES

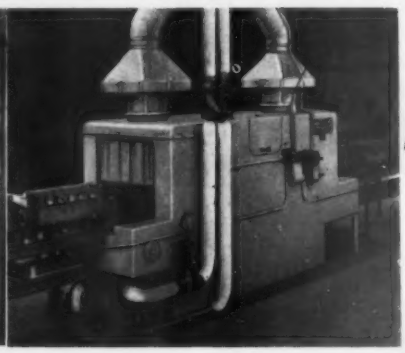
FP3/1/P.321

The most practical plant for Cleaning METAL PARTS

PRIOR TO ASSEMBLY, and BEFORE and AFTER REPAIRS



Supplied for the washing and drying of Tractor parts. Crank Shafts, Sumps, Pressings, etc.



A model 'A' machine, washing parts of motor car engines prior to assembly.

Dawson Metal Parts cleaning machines are supplied for all branches of the engineering industry. Their chief characteristics are robustness of design, small number of working parts and simplicity of operation. Space only permits the illustration of four of the many types of machines built for quick economical washing and drying of Metal Parts.

Sole Distributors

DRUMMOND - ASQUITH (Sales) LTD., King Edward House, New St., Birmingham

Telephone—Midland 3431

Manufacturers—DAWSON BROS. LTD., Gomersal, LEEDS *Tel.—Cleckheaton 1080 (5 lines)*

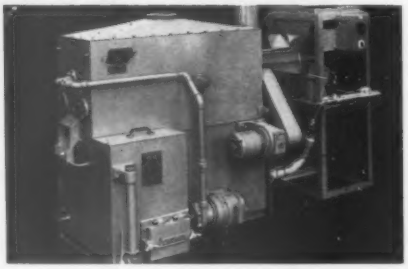
London Works—406 Roding Lane South, Woodford Green, Essex. *Tel.—Wanstead 7777 (4 lines)*

A 'Junior' type machine supplied to a Midlands Motor Car Works.

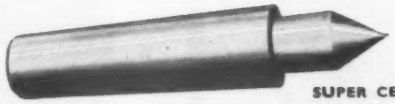
Dawson

DE-GREASING MACHINES

A Rotary Drum machine for removing swarf and grease from small components.



BE RIGHT IN THE CENTRE



SUPER CENTRE

A permanent Hardened and Ground Socket with RENEWABLE HIGH SPEED STEEL INSERT. Standard inter-changeable inserts enable centre to be quickly replaced.

STANDARD SOLID CENTRES

Precision ground to give perfect concentricity. Tapers to standard gauges. Made in High Grade CARBON ALLOY STEEL, or HIGH SPEED STEEL BUTT WELDED.

'ARCHER'

BALL & ROLLER BEARING TYPES

REVOLVING CENTRES

All types of centres are made from the best grade steel, and are designed to give greater efficiency. Take higher speeds, and remain true under the most strenuous conditions of present day engineering.

The
ARCHER
REVOLVING CENTRES

Revolve with the work and can thus stand up to the higher speeds and heavier work demanded by modern engineering practice.

ARCHER SMALL TOOLS

✱ *ASK FOR LISTS NOS. 508 and 85*

FRANK GUYLEE & SON LTD

ARCHER TOOL WORKS · MILLHOUSES · SHEFFIELD · 8

"BROOMWADE" aids industry

Photograph by courtesy of the Glacier Metal Co., Ltd.

Glacier Metal Co. Ltd.—well-known manufacturers of Plain Bearings—use an imposing battery of " Broomwade " air compressors for operating foundry moulding machines, core blowing machines and also for operating in their Machine Shops pneumatic chucks, clamping devices, etc. The compressors are also used for supplying power to a range of specially designed machine tools.

The group illustrated includes four type EH compressors and one D type—all operating at 100 lbs. per sq. in. pressure.

A very impressive number of famous engineering companies, themselves concerned with work of precision, have selected " BROOMWADE " air compressors and pneumatic tools to facilitate the manufacture of their products.

The " BROOMWADE " organisation invites consultation on any problems involving the use of compressed air. Service engineers are available in most countries.

"BROOMWADE"

Air Compressors & Pneumatic Tools

BROOM & WADE LTD., P.O. BOX No. 7, HIGH WYCOMBE, ENGLAND

Telephone: High Wycombe 1630 (10 lines) Telegrams: "Broom" High Wycombe

257SAS

For work above the average

PRESS TOOLS
SPECIAL TOOLS
DIE-CASTING TOOLS
PLASTIC MOULDS

... JIGS AND FIXTURES BY ...

UNIVERSAL TOOLS LTD

TRAMWAY PATH, MITCHAM, SURREY. MITcham 1624

Unique

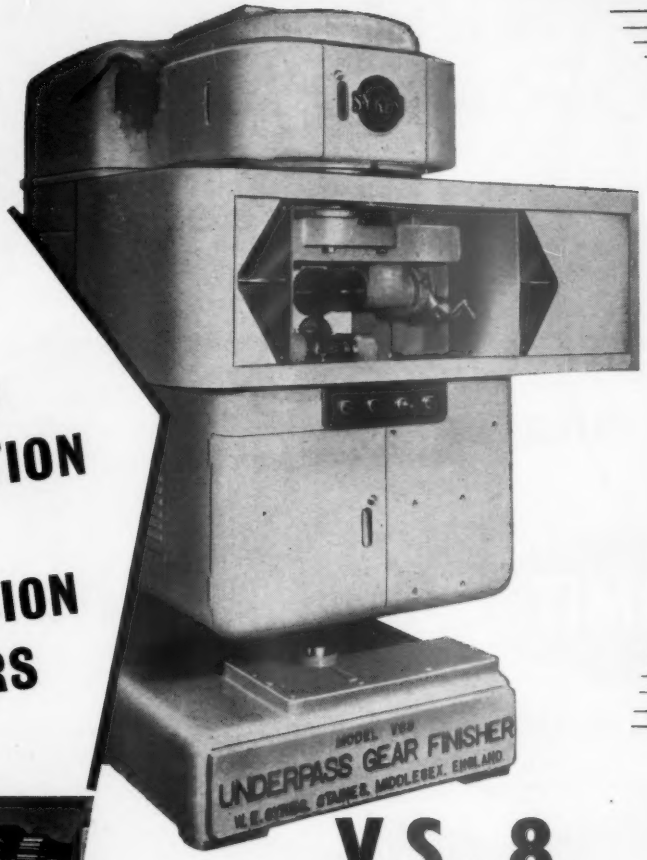
"Newallastic" bolts and studs have qualities which are absolutely unique. They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method

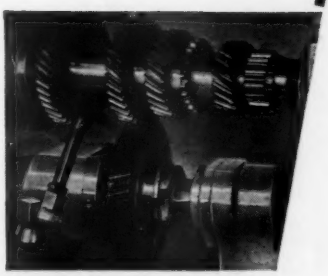
G. P. Newall & Co., Ltd.

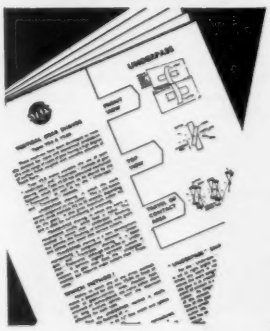
POSSILPARK GLASGOW · N

SYKES

for
RAPID
PRODUCTION
of
PRECISION
GEARS







VS.8

UNDERPASS ROTARY GEAR SHAVING MACHINE

This rapid and economical method of precision gear production needs no particular skill. Concentricity and tooth profile accuracy are improved and a high degree of finish is obtained.

Profile modifications — both Axial and Transverse — can be readily incorporated and Shaving can be carried out close up to a shoulder where grinding would be impossible.

← **This useful brochure on Gear Shaving sent on request.**

You are cordially invited to inspect these machines in operation at our works.
(Waterloo to Staines 30 minutes)

W. E. SYKES LIMITED

STAINES · MIDDLESEX · ENGLAND

'Phone: STAINES 4281 (6 *lines*) *'Grams:* 'SYKUTTER, STAINES'

Canada: Sykes Tool Corporation Ltd., 123/131 York Street, Toronto.
Australia: W. E. Sykes Ltd., 8 Ricketty Street, Mascot, Sydney, N.S.W.

don't pull a long face over filters...

. . . . consult the specialists with your own filtration or straining problem. For over 25 years Intermit have produced to customers' own requirements for thousands of different applications.

May we tell you about some of them?

Illustrations :
Pipe line strainers in perforated metal—Monel, brass, copper, stainless steel, etc. Drain plate filters—produced with any mesh size and in any metal.

INTERMIT **FILTERS · SCREENS · STRAINERS**

INTERMIT LIMITED · 37, Bradford Street · Birmingham, 5 · *MIDland 3492.*

SMT 12346

ON LAND - IN THE AIR - ON THE SEA

ME

UNIVERSAL JOINTS

Are unsurpassed for Efficiency, Power and Endurance

ME Joints are manufactured under ideal conditions, by specially designed single purpose plant. Rigid inspection of components is made after each operation, and heat treatments are scientifically controlled

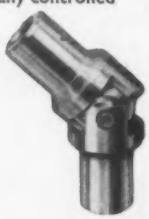
AVAILABLE FOR ALL TYPES AND SIZES OF JOINTS

'HOOKES' TYPE UNIVERSAL JOINT

For less severe duty than the 'Patent' joint. Withstands some tension or compression loads.

'ME' PATENT UNIVERSAL BALL JOINT

Combines high load carrying capacity, simplicity of design and utmost reliability. 92%–98% efficient (N.P.L. certified).



'HOOKES' TYPE LIGHT SERIES UNIVERSAL JOINT

Designed for light duty. Moderate tension and compression loads are allowable.

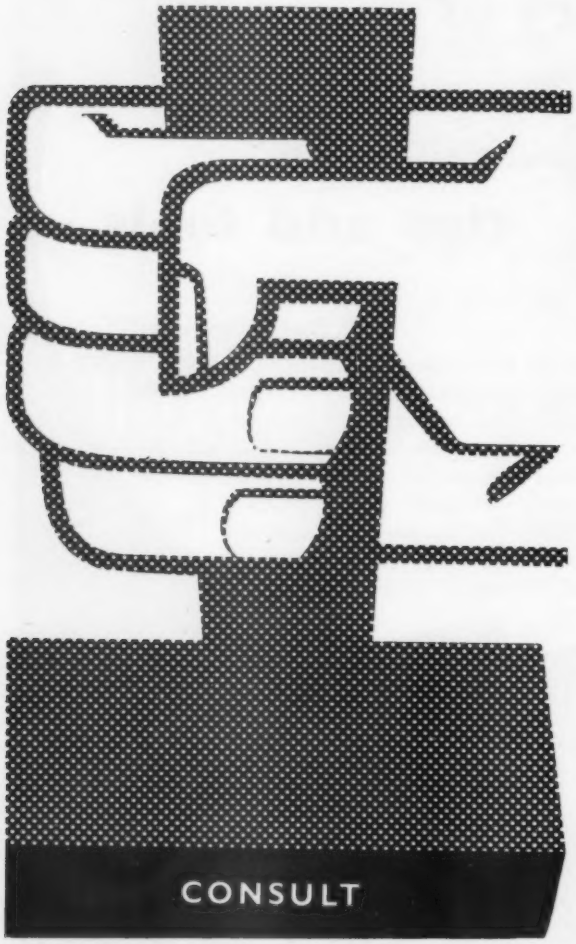
THE MOLLART ENGINEERING COMPANY LTD.
KINGSTON BY-PASS, SURBITON, SURREY, ENGLAND

Tel: ELMBRIDGE 0033/7 **'Grams.: PRECISION, SURBITON**

Air Ministry Gauge Test House Authority 89755/31

Hard and fast
the story of
Cutanit
tips and tools
NO. 2 IN A SERIES:
CONSISTENT HIGH QUALITY
In the early stages of Cutanit Manufacture, fine control of the main elements — tungsten, titanium, tantalum, cobalt, and carbon — is maintained and a constant check on the consistency is made by Metro-Cutanit with the aid of the Absorptiometer and Spectrograph illustrated. By such means it is ensured that Cutanit tips and tools are unequalled for their consistent properties and consistent value throughout industry.
WM JESSOP & SONS LTD
BRIGHTSIDE WORKS SHEFFIELD
J J SAVILLE & CO LTD
TRIUMPH WORKS SHEFFIELD

For pressure die-castings



SPARKLETS

LIMITED

(DEPT. DB)
QUEEN STREET, LONDON, N.17

'We're going to need really first rate rubber...

For over a century when a problem like that has arisen, men responsible for production planning and buying have thought at once of P. B. Cow. Knowing the vast resources of the P. B. Cow organisation were always at their service.

Today, we are proud to offer an *unparalleled service to every industry.* A large team of experts, experienced in the latest and most up-to-date methods of production, is available to solve *your* problem. Experts who will bring to the job all the knowledge acquired in advising and supplying leading companies the world over.

So whenever you have a problem that concerns rubber, write or phone for one of our technicians to call. He will be fully qualified to help and advise you.

P. B. COW SERVE
Agriculture
Dairy
Motor Car
Radio
Television
Shipbuilding
Public Utilities
General Engineering
Pharmaceutical

WE SPECIALISE IN:
Production of Rubber to Metal bonded parts, Anti-vibration and Resilient Mountings, Oil Seals, Handmade Fabricated Parts, Proofed Fabrics in Natural or Synthetic Rubbers for every purpose, and Air Buoyancy work of all descriptions.

...get in touch with P. B. COW

RUBBER THAT IS RUBBER

P. B. Cow & Company Ltd., Rubber Manufacturing Specialists for every Industry. Industrial Division: 470 Streatham High Road, London, S.W.16. Phone: Pollards 4481.

PBC

Costing...

★ expenditure controlled

★ waste eliminated

★ current facts—not past history

★ more detail in less time

the very job for

Costing may be only one process in accounting but it is always necessary wherever labour is employed and materials consumed. Hollerith takes the whole of accountancy in its stride—but costing is an admirable starting point for an enquiry. It costs nothing to find out what Hollerith might save you.

HOLLERITH REGD.
Electrical PUNCHED CARD ACCOUNTING

THE BRITISH TABULATING MACHINE CO. LTD

Head Office: 17 Park Lane · London · W.1 *Telephone:* HYDe Park 8155

Offices in principal cities in Great Britain and Oversea

JPE/5312/146

The GLEDHILL-BROOK J·M·C

PORTABLE TIME RECORDER

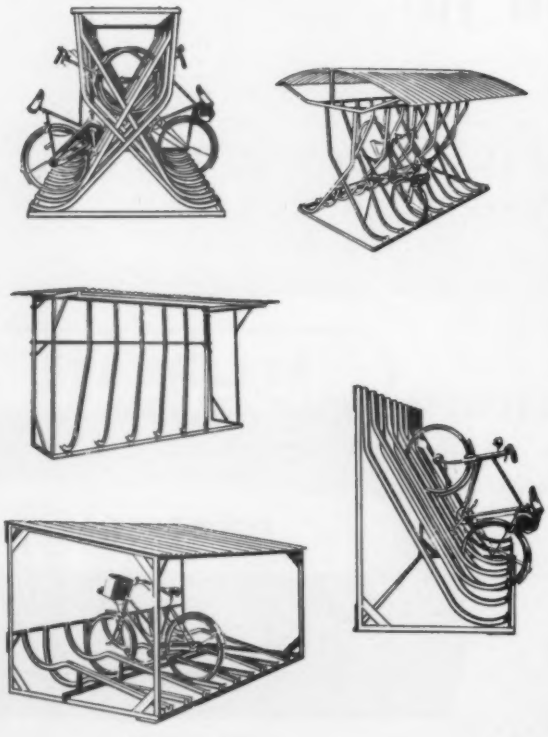
This handy, portable Time Recorder meets every requirement in small establishments but it is designed to supplement rather than replace the range of large scale GLEDHILL-BROOK Clipper models.

The J.M.C. Clipper prints on the face of the card—where the name appears—recording arrivals, departures and the job process on and off.

Well built steel case with cellulose finish and 8-day mechanical clock movement. " G.B." patent electric movement if required.

For full details and illustrated leaflet write to

GLEDHILL-BROOK TIME RECORDERS LIMITED
20 EMPIRE WORKS, HUDDERSFIELD.



THERE IS AN ABIX CYCLE STAND TO SUIT EVERY REQUIREMENT

ABIX Cycle Stands are constructed of steel throughout, stove enamelled green. Roof sheeting is normally of galvanised corrugated sheets. If required, sheeting can be supplied in Aluminium, Asbestos, or Robertson Protected Metal.

● **THERE ARE 26 DIFFERENT TYPES FROM WHICH TO CHOOSE**

OVER A QUARTER OF A CENTURY'S EXPERIENCE IN CYCLE STAND MANUFACTURING

Please write for illustrated Catalogue to:

ABIX (METAL INDUSTRIES) LTD
FACTORY EQUIPMENT SPECIALISTS

Taybridge House, Taybridge Road, Battersea, London S.W.11

'Phone: Battersea 8666-7 'Grams: Abix, Batt, London

ALLOY STEEL BARS

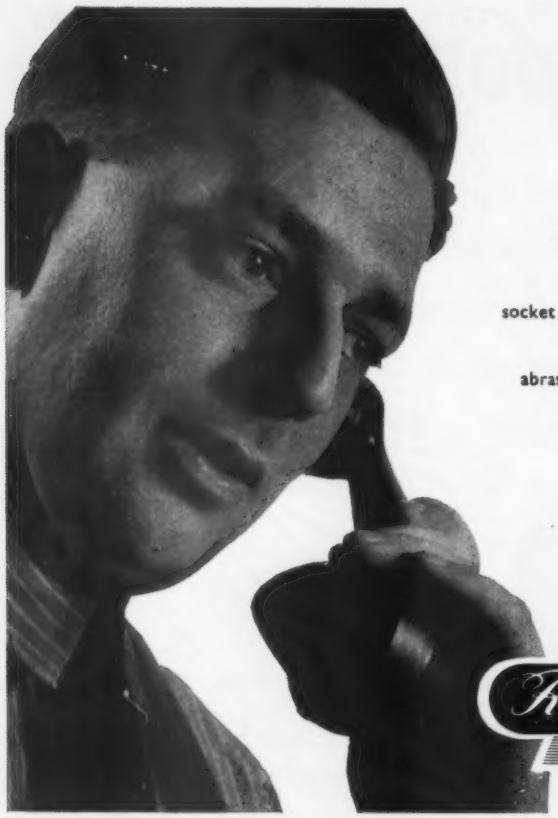
FOR

HIGHLY STRESSED PARTS

BY

FIRTH BROWN

THOS. FIRTH & JOHN BROWN LIMITED SHEFFIELD



★YES SIR.....WE CAN DELIVER FROM STOCK!

Whatever your needs in machine shop equipment and supplies, we are organised to give you an "off the shelf" service . . . . . .

We hold comprehensive stocks of "Intal" twist drills: J. & S. small tools; H. S. S. milling cutters and reamers; lathe and drill chucks; socket head screws; precision tools; "Galtona" ground thread taps; cut thread taps and dies; "Galtona O.K." serrated blade milling cutters; "Carborundum" grinding wheels and all abrasive products; belting, pulleys and millgearing; millfurnishing; machine tools and equipment, etc.....etc.....in fact,

EVERYTHING FOR THE ENGINEERING SHOP.

★ TELEPHONE
BIRMINGHAM (HEAD OFFICE)
ASTON CROSS 3001
LONDON OFFICE
MARYLAND 2564
LEEDS OFFICE
LEEDS 21212

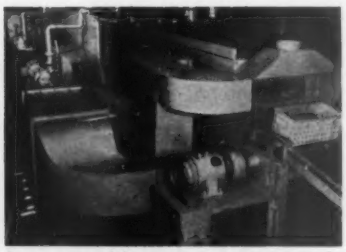
Richard Lloyd Limited
STEELHOUSE WORKS · OLIVER STREET · BIRMINGHAM 7
"Telephone Aston Cross 3001 (3 lines)" "Telegrams Cogs, Birmingham"
NORTHERN AREA OFFICE : A. V. Green, Britannia House, Wellington St., Leeds, 1.
LONDON AREA OFFICE : A. J. Percy, 240, Romford Road, Forest Gate, London, E.7.

Bratby

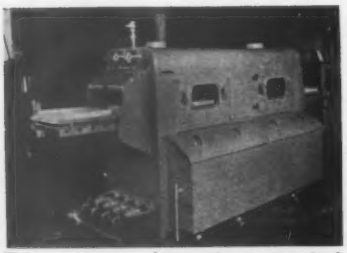
HERE ARE THREE EXAMPLES

INDUSTRIAL CLEANING MACHINES
can be designed to meet your particular cleaning problems

This illustration shows a machine cleaning crank cases in the production line. It is equally capable of cleaning small parts in baskets.



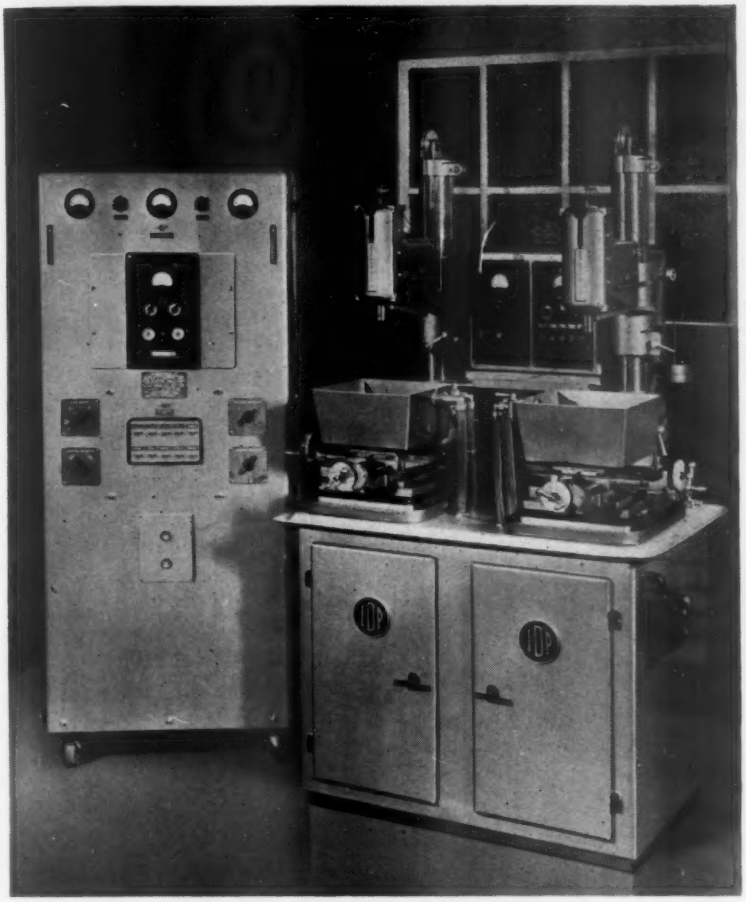
A power driven conveyor system is employed with this cleaning machine for ball bearings.



Trays carrying the work are pushed through on a roller conveyor by hand in this cleaning installation.

Whilst offering a very wide variety of standard cleaning equipment, it is BRATBY policy, wherever possible to design the machine to meet the particular cleaning problem. Careful study of each individual problem ensures maximum efficiency and economy of the plant in operation. The illustrations show but a few of the specific types of Cleaning Machines designed by BRATBY for individual needs.

Designed and Manufactured by BRATBY & HINCHLIFFE LTD · SANDFORD STREET · ANCOATS · MANCHESTER 4



For production of all types of dies and form tools.

The leading manufacturers of spark machining equipment in the world, have pleasure in announcing their latest

SPARCATRON Mk. II Model

With double head.

This addition to the Sparcatron range of machines for spark machining has been produced as the result of requests for an equipment for use with large section electrodes to be operated to very close limits, and can be supplied with two heads as illustrated, or with a single head.

The twin head model can be easily worked by one operator, and the heads operated separately, so that production per man hour is doubled.

A further two or more heads may be used in conjunction with the main control unit in some circumstances.

Manufactured by:

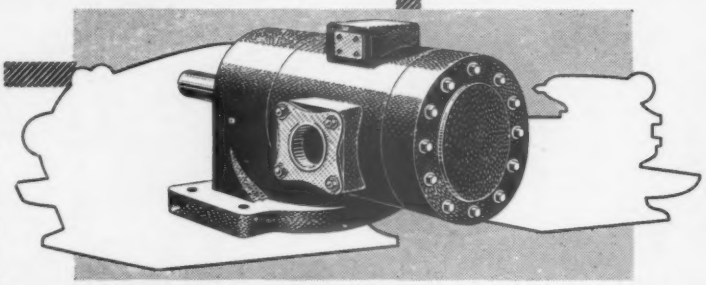
IMPREGNATED DIAMOND PRODUCTS LTD., GLOUCESTER, ENGLAND

TELEPHONE 21164 (3 LINES) TELEGRAMS IMPREG GLOUCESTER

Easier movements . . Longer life . . thanks to *OIL HYDRAULICS*

Hydraulically-operated machine tools fed with VETA oils are more efficient, thanks to reduced friction and easier movements. This is made possible by their flow characteristics at working temperatures and low demulsification value. There are viscosities suited to operate all hydraulic systems. VETA oils are inhibitor treated to ensure retention of lubrication value under service conditions of heat, high circulation rates and optimum pressures. Says one Plant Engineer, "VETA oils are certainly reliable; we never have any trouble with any of our hydraulics".

Write today for a copy of our 20 page booklet "Machine Tool Lubrication"



FLETCHER MILLER

Machine Tool Lubricants

FOR *correct* MACHINE TOOL LUBRICATION

VETA — FOR HYDRAULIC SYSTEMS GENERALLY

GENA — THE MACHINE TOOL LUBRICANT

ALMARINE — FOR ALL GREASE POINTS

FLETCHER MILLER LTD
ALMA MILLS . HYDE . CHESHIRE
Telephone: Hyde 781 (5 lines) *Telegrams: Emulsion Hyde*

MTL 23

Absolutely dependable

HORSTMANN

Specialists in PRECISION

Horstmann Precision Gauges are noted for their accuracy and long life.

The new patent Caliper Gauge Model 52, embodies features which ensure easy handling and rapid but accurate gauging.

It is particularly suitable for shouldered work.

Send today for descriptive leaflet.

THE HORSTMANN GEAR CO. LTD.
NEWBRIDGE WORKS · BATH · ENGLAND
Telephone: BATH 7241 (3 lines)

WATTS

The Clinometer for the Engineer

Accuracies up to 10 seconds

Write for list JPE/25 to

HILGER & WATTS LTD

WATTS DIVISION

48, Addington Square, London, S.E.5

Member of the Export Marketing Company BESTEC

Standard
GROUND THREAD TAPS
from stock

Your safe standard tap for all the "fussy" jobs as well as the straightforward ones. All Harris Taps are precision ground from the solid to give you more accurate threaded holes, faster and at lower cost

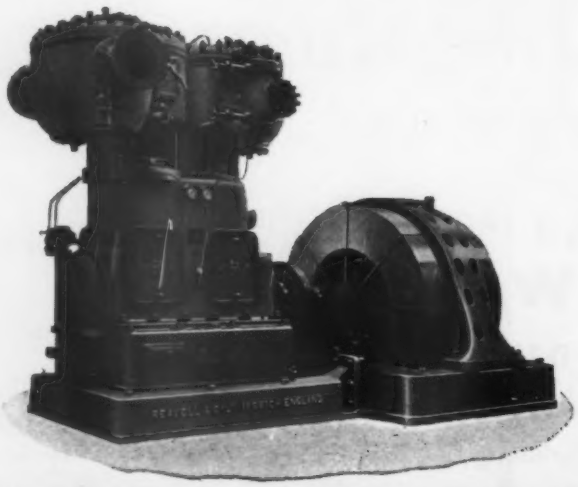
JOHN HARRIS TOOLS LTD., WARWICK phone: 1041 (4 lines)

London Sales Office: 5, Victoria Street, S.W.1. Telephone: ABBey 3037 & 5069 Glasgow Sales Office: 74, York Street. Telephone: CENtral 3187

WHEN YOU ARE WANTING NEW

AIR COMPRESSORS

DO NOT FORGET THAT WE HAVE
A COMPLETE RANGE TO SUIT ALL DUTIES



Whatever it is you need—large or small capacity—high or low pressure—we can supply the best machine for the purpose, and our fifty years of specialised experience are at your service.

REAVELL & CO. LTD.
IPSWICH

Telegrams: Reavell, Ipswich Telephone Nos.: 2124-5

Quo Vadis?

Edgar Allen & Co. Limited can supply seven steels for tools working at elevated temperatures, perfected by their long experience of industry's requirements for dies, punches, rivet snaps, mandrels, etc.

The right road to success
in working ferrous and
non-ferrous metals

- **EDGAR ALLEN No. 5 HOT DIE**
- **MAXINIUM**
- **LOMINIUM**
- **MAXNAP**
- **A.M.I. A.M.3.**
- **Y.W.A.**

Write for Catalogue, using request form

To **Edgar Allen and Co., Ltd., Sheffield 9.**

Please post "Special Alloy Tool Steels" Catalogue to :—

Name.....

Firm .....

Address.....

.....

I.P.E.

EDGAR ALLEN & CO·LIMITED
IMPERIAL STEEL WORKS:-SHEFFIELD·9

TELEPHONE: SHEFFIELD 41054. TELEGRAMS: ALLEN, SHEFFIELD 9

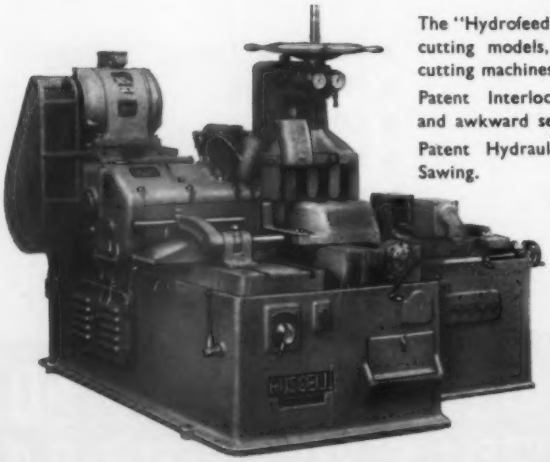
. . . twice as easy!
with the
PRIORITY
PUNCH GRIP

The " PRIORITY " punch grip has been designed to avoid damage to the fingers of the punch user. It holds firmly all sizes of " PRIORITY " punches and allows a really hard blow to be struck without the risk of jarring.
The punch grip is strongly made in aluminium and is designed to sit easily in the hand.

EDWARD PRYOR & SON LTD
BROOM STREET **SHEFFIELD**

RUSSELL

METAL SAWING MACHINES



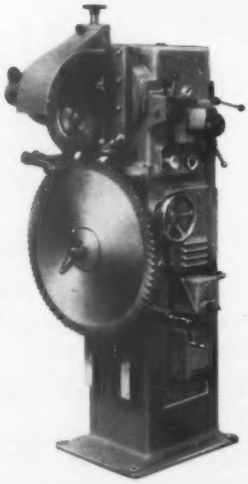
The "Hydrofeed" range includes Straight and Angular cutting models, "Automatics," and special Billet cutting machines.

Patent Interlocking Vices can grip several bars and awkward sections.

Patent Hydraulic Circuit specially designed for Sawing.

Capacities up to 13½" diameter or 24" × 10" R.S.J.

'HYDROFEED' COLD SAWING MACHINE
Automatic bar feed.

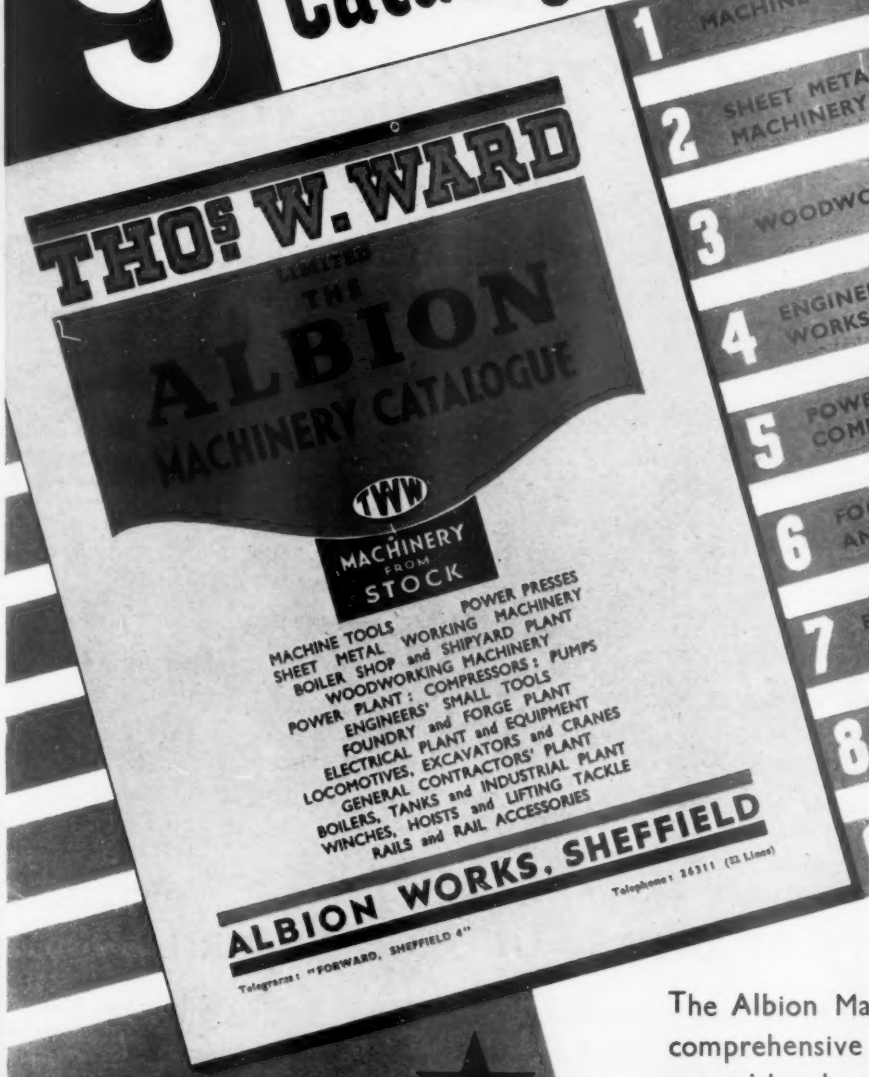


SAW SHARPENING MACHINE
Capacity 11" to 48" blades

S. RUSSELL & SONS LIMITED • LEICESTER • ENGLAND

9 Catalogues in one.....

1 MACHINE TOOLS
2 SHEET METAL WORKING MACHINERY
3 WOODWORKING MACHINERY
4 ENGINEERS' SMALL TOOLS AND WORKSHOP ACCESSORIES
5 POWER PLANT, COMPRESSORS AND PUMPS
6 FOUNDRY AND FORGE PLANT
7 ELECTRICAL PLANT AND EQUIPMENT
8 LOCOS., CRANES AND CONTRACTORS' PLANT
9 BOILERS AND TANKS



The Albion Machinery catalogue is a comprehensive stock list of new and second hand machines revised and reprinted every two or three months. *Ask for a copy to be sent to you regularly.*

ANOTHER ASPECT OF TWW SERVICE

THOS. W. WARD LTD

ALBION WORKS · SHEFFIELD

TELEPHONE: 26311 (22 Lines) • TELEGRAMS "FORWARD, SHEFFIELD"

LONDON OFFICE: BRETTENHAM HOUSE · LANCASTER PLACE · STRAND · W.C.2

A MARBAIX ANNOUNCEMENT

DELTA MILWAUKEE
Registered Trade Mark

AIR POWERED HYDRAULIC DRILL UNITS ADD UP TO PROFIT

—because users get Increased Production at

LOWER COST

Patent No. 710, 335
Patents applied for in all countries

3 TYPES OF DRIVES—

DIRECT DRIVE,
GEAR REDUCTION DRIVE,
PULLEY DRIVE.

We will supply the heads, or build special machines incorporating them, to meet specific requirements.

Regulated Power FOR DRILLING, REAMING, CENTRING, SPOT-FACING, HOLLOW MILLING.

CAPACITY OF UNITS—UP TO 1" dia. DRILL

ELECTRIC MOTOR merely gives power to rotate spindle.

AIR PRESSURE provides power to move spindle forward.

OIL PRESSURE controls spindle movement for RAPID approach, controlled power feed.

CONTROLLED POWER FEED is fully hydraulic and independent of electric motor.

SPINDLE TRAVEL—4" maximum.

RAPID APPROACH. Rate—280 inches/minute (Constant) Travel. Adjustable 0 to full stroke (or any portion). Accurately adjusted to plus or minus .0005".

RAPID RETURN. Rate—200 inches/minute.

TRAVEL. From any spindle stop position.

AIR CONSUMPTION economical, available thrust up to 600 lb. at 80 p.s.i.

CAN BE MOUNTED IN ANY POSITION, for remote control, automatic or manual operation.

Learn more about these efficient units ● *Send now for free informative literature*

Manufactured by :-

GASTON E. MARBAIX LTD

DEVONSHIRE HOUSE, VICARAGE CRESCENT,
BATTERSEA LONDON, S.W.11
PHONE BATTERSEA 8888 (8 lines)

ANNOUNCING

BARNESDRIL KLEENAL UNITS

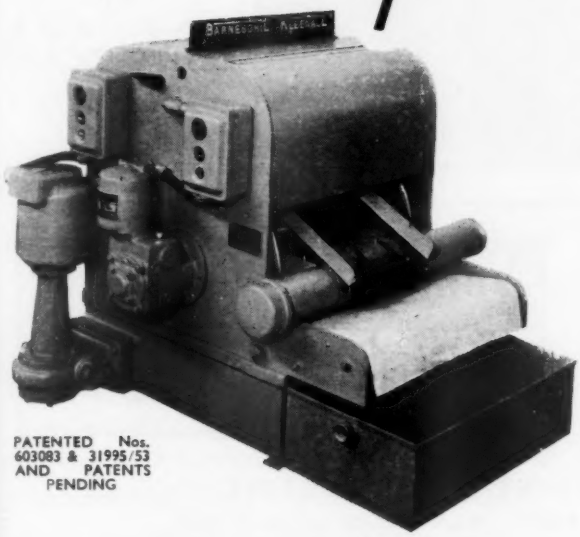
IMPROVED COOLANT FILTRATION

...the BARNESDRIL way

Combines Magnetic Separation with Fabric Filtration

... and CLEAN Coolants Give You

- *Improved Finish*
- *Longer Tool Life*
- *Increased Production*
- *Reduced Machine Wear*
- *Better Sanitation*



PATENTED Nos. 603083 & 31995/53 AND PATENTS PENDING

All metallic sludge and abrasives are completely removed in Economical, Automatic Operation through rapid, double-cleansing action. Write for full information.

Kleenall Filters Are Plant Proven On Our Own Production Equipment

FABRIC BARNESDRIL MAGNETIC

FILTRATION DIVISION

GASTON E. MARBAIX LTD

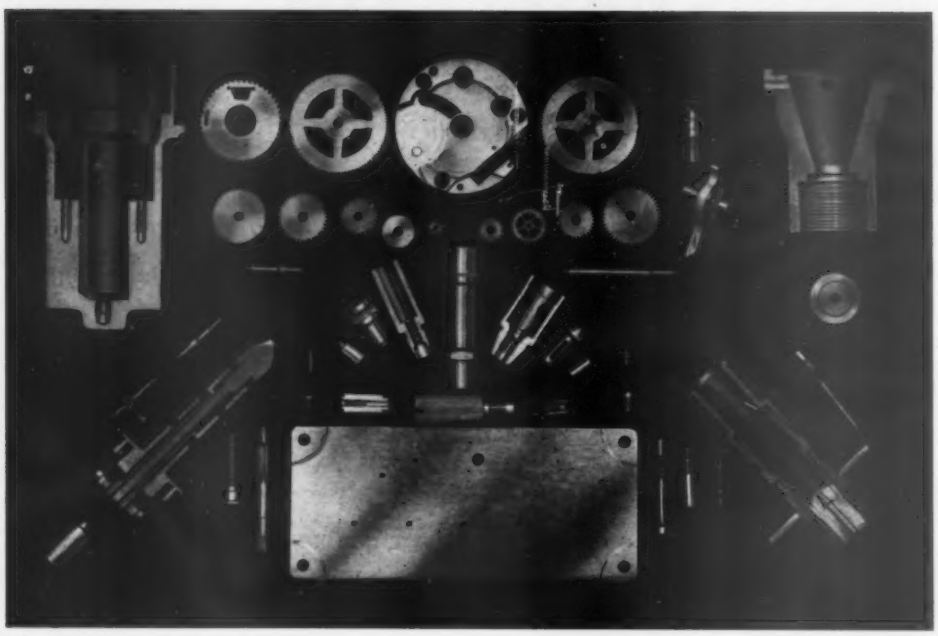
DEVONSHIRE HOUSE, VICARAGE CRESCENT, BATTERSEA LONDON, S.W.11
PHONE BATTERSEA 8888 (8 lines)

BRAY

ACCESSORIES — LIMITED

LEICESTER PLACE, LEEDS 2.

Tel: 20981/9 Grams: "BRAYACS LEEDS 2"



MASS PRODUCTION OF PRECISION COMPONENTS & ASSEMBLIES TO FINE TOLERANCES BY NON-SELECTIVE METHODS

CAMERAS—

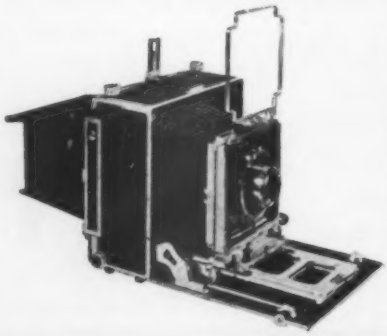
INDUSTRIAL

OR FOR PERSONAL USE

You can rely on PC PELLING & CROSS LTD

VISIT OUR STAND B 23 AT EARLS COURT

FACTORY EQUIPMENT EXHIBITION—March 28th to April 2nd



Long experience as suppliers of photographic and cine equipment to industrial and government organisations forms the basis of a Camera Sales Service that cannot be bettered throughout the British Isles. We shall be exhibiting Industrial Cameras, Enlargers, Cine Cameras and Projectors together with a selection of modern English and Continental cameras suitable for the personal use of executives and sales representatives.

One of our principals is available at any time.

Please address any correspondence to PHOTO-LAB. DEPT.

PELLING & CROSS, LTD., 104, BAKER STREET, LONDON, W.1. WELbeck 9682/3.

THIS YEAR AT EARLS COURT

Third National

FACTORY EQUIPMENT EXHIBITION

EARLS COURT · LONDON · SW5
28th March to 2nd April · Daily 10-7
(SATURDAY 10-5)
ADMISSION 2/6

DON'T MISS the third and biggest Factory Equipment Exhibition — this year at Britain's finest exhibition centre. Whether yours is a large industrial concern or a small progressive works, you are bound to find plenty to interest you in this comprehensive exhibition. See the new equipment and new methods for increasing efficiency, stepping-up production, and reducing costs. Attend the conferences on vital industrial problems and the protective clothing parades. It will pay you to visit the Factory Equipment Exhibition, and to send your staff too.

Complimentary Season Ticket will be sent to Production Engineers on application to: The Organiser, Factory Equipment Exhibition (Dept. E1), 117 Kingsway, W.C.2.

see the latest equipment demonstrated

FACTORY CONSTRUCTION · MAINTENANCE
FUEL ECONOMY
MECHANICAL HANDLING · STORAGE
PACKING · WORKS OFFICE
WELFARE AND SAFETY

'A better way of doing things'

The exhibition is sponsored by 'The Factory Manager' and 'Factory Equipment News'

for enduring resistance

All products of aluminium and its alloys can be given longer life and protection against corrosion and abrasion by our renowned Hard Anodizing treatment. These finishes have been subjected to the most rigorous testing and have proved their worth. The many applications of this process include any sliding surfaces such as pistons, valves, etc., fuel pipe unions, gear teeth, pump rotors and side plates and coarse screw threads. Our Technical Sales Manager is at your service to discuss your problems. His telephone extension is 14.

ALUMILITE HARD ANODISING

ALUMILITE AND ALZAK LIMITED

PRIORY WORKS, MERTON ABBEY, LONDON, S.W.19

TEL: LIBERTY 7641 CRAMS
ALUMILITED WIMBLE LONDON

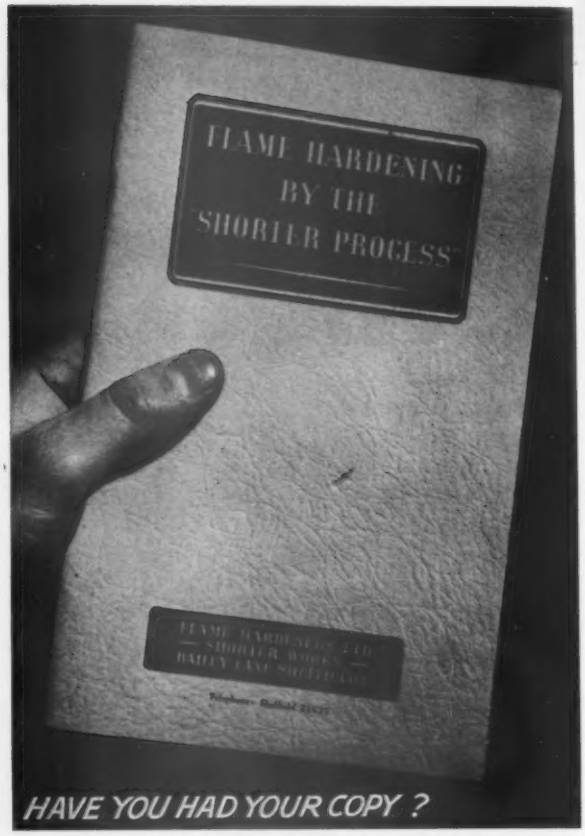
no need to look at the name

You can tell as soon as you pick it up. The balance, the sharp, precision cut teeth—just as a good file should be. And . . . .

if it's a good file it's a

BEDFORD

JOHN BEDFORD AND SONS LTD LION WORKS SHEFFIELD



HAVE YOU HAD YOUR COPY ?

GEARS

OF PRECISION

SPURS
SPIRALS
BEVELS
WORMS
WHEELS

Supplied complete or from customer's blanks.

Our service is reliable and delivery prompt.

10

RELIANCE GEAR & ENGINEERING CO. (SALFORD) LTD
DICKINSON STREET SPRINGFIELD LANE SALFORD 3
Phone BLAckfriars 0164 & 1715 Grams MOTOGEARS

★

ROBERTSON

Q-GRATING

TRADE MARK

the open steel flooring with every advantage

★

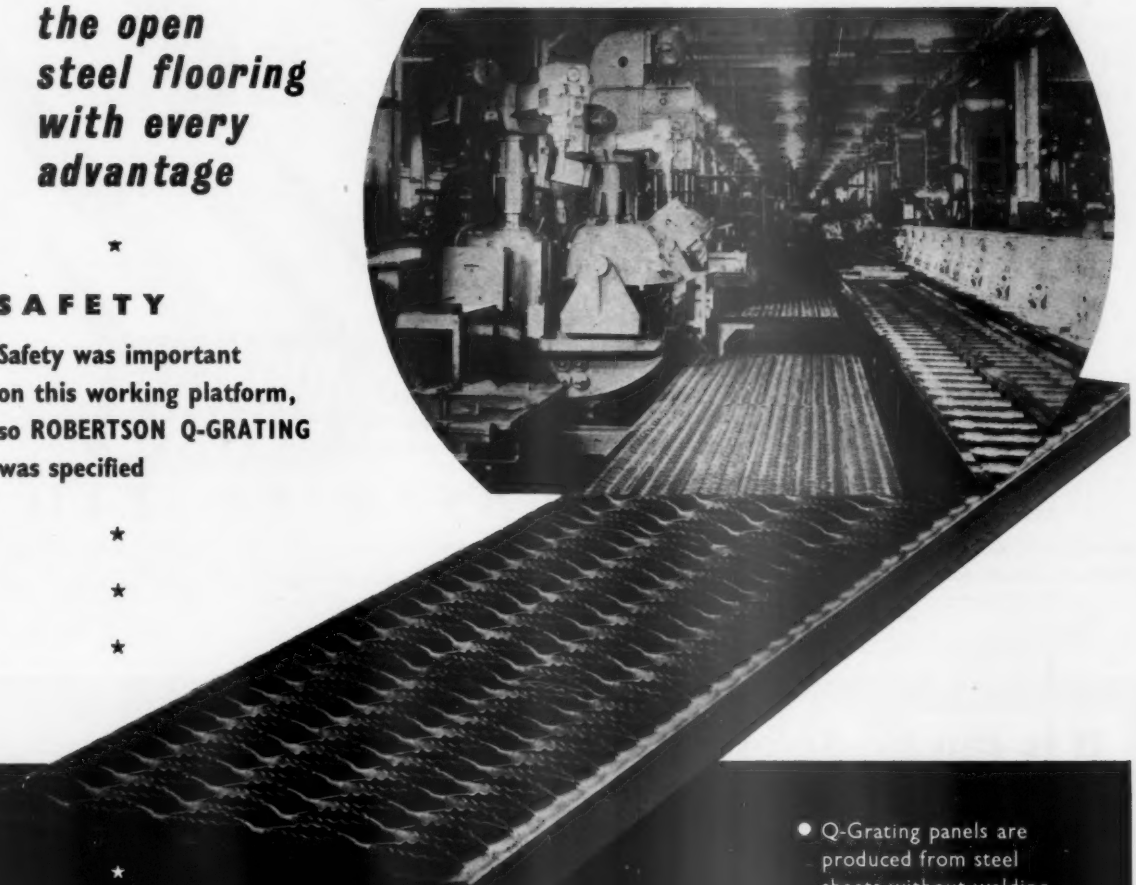
SAFETY

Safety was important on this working platform, so ROBERTSON Q-GRATING was specified

★

★

★



★

★

- Q-Grating panels are produced from steel sheets without welding, riveting or expanding operations.
- Q-Grating provides maximum strength for minimum weight.
- Q-Grating permits a free flow of air and ample light entry.
- Special shapes easily made.

For **STAIRWAYS**
For **WORKING PLATFORMS**
For **ALL SITUATIONS** *where secure foothold is vital*

Write today for literature

ROBERTSON THAIN LIMITED

ELLESMERE PORT · WIRRAL · CHESHIRE

Telephone: Ellesmere Port 2341 · Telegrams: Robertroof, Ellesmere Port

Sales Offices: LONDON · GLASGOW · BELFAST · BIRMINGHAM · NEWCASTLE · LIVERPOOL · SHEFFIELD · MANCHESTER · CARDIFF

Agents in most countries throughout the World

Marsh

Three Centuries of Sheffield Steel

MARSH CYC HIGH SPEED TOOLS

MARSH CARBON STEEL TOOLS

A comprehensive range of these cutting tools is maintained for immediate delivery

1631-1955

Here's a background of real practical experience, and a sure knowledge of the world's finest tool steels, with an up to the minute service on your cutting tool requirements.

MARSH BROTHERS & CO LTD

PONDS STEEL WORKS PO BOX 82 SHEFFIELD 1 TELEPHONE: SHEFFIELD 20194 TELEGRAMS: "MARSH SHEFFIELD"

LONDON OFFICE: WARDROBE COURT AND CHAMBERS 146a QUEEN VICTORIA ST EC4 TELEPHONE: CITY 2363-4

If it can be Riveted . . .

HERE IS HOW YOU CAN SPEED UP THE JOB AND CUT COSTS.

If you produce rivetted assemblies where speed in operation and a neat appearance are as important as a properly formed rivet head—it will pay you to investigate T.T. Rivet Spinning machines. The wide range of machines available are suitable for cold rivetting in all sizes up to ¼"; diam. mild steel. It includes bench and floor models, air and foot operated and "Duplex" spinners for heading both ends of pins for hinges, chains, etc.

Write for full details and latest literature.

TT

RIVET SPINNING MACHINE

R.S.J. VMD. AE. ¼ in. Capacity. Air operated, cabinet base.

Ask for a demonstration. Full technichal advisory service available. Samples of articles would be appreciated.

TURNER

MACHINE TOOLS LTD

63-68, PRINCIP ST., BIRMINGHAM, 4

Telephone : Aston Cross 2244.

From Drawing Office to finished product

Leytonstone

JIG & TOOL Co LTD

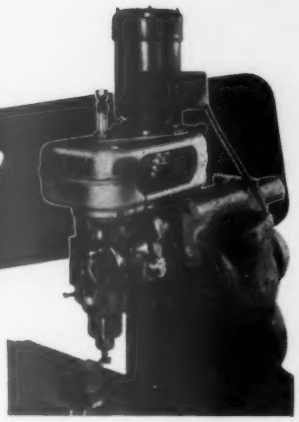
Fully A.I.D. approved Ref. No. 793672.38

RATCHET SPANNERS and a complete range of "Leytool" Hand Tools

JIGS FIXTURES PRESS TOOLS and every type of Precision Engineering to close limits and high quality

LEYTOOL WORKS, HIGH RD., LEYTON, LONDON, E.10 Leytonstone 5022-4

Introducing the New...



Catmur
HIGH SPEED VERTICAL MILLING ATTACHMENT

WITH SWIVEL HEAD

This High Speed Milling Attachment is the latest addition to the Catmur range. Supplied complete with motor and switch, the head is designed to mount on any standard horizontal miller and some types of vertical mill. The high speed precision cutter spindle is suitable for die sinking, tool milling, etc.

Quill travel 3½ in. Quill Diameter 3 in. 6 speeds, 400 to 3,670 r.p.m.

¾ h.p. Motor at 1,420 r.p.m. Belt housing and motor turns through 360 deg.

Send for Illustrated Leaflet.

SPECIAL FEATURES

- Extra long quill housing with lapped bore of full bearing area.
- Nitride hardened quill.
- Mounting bolts do NOT straddle quill housing.
- Spindle mounted on two pairs of precision ball races.
- Built-in stop for accurate milling without obstruction of operator's view.

CATMUR MACHINE TOOL CORPORATION LIMITED

103 LANCASTER ROAD · LADBROKE GROVE · LONDON · W.11 *'Phone PARK 9451/2*

Rainbow

For low all round cost *The* **NEW**

MYFORD

M.G.12 Cylindrical Grinder

Introducing **THE NEW MG12 CYLINDRICAL GRINDING MACHINE WHICH IS WORTH YOUR INVESTIGATION**

- ★ *Nitrided Wheel Spindle* (Removable Unit Type)
- ★ *Revolving Spindle Workhead*
- ★ *Multi-Speed Electrics 75-730 R.P.M.*
- ★ *Internal Grinding Attachment available, etc.*

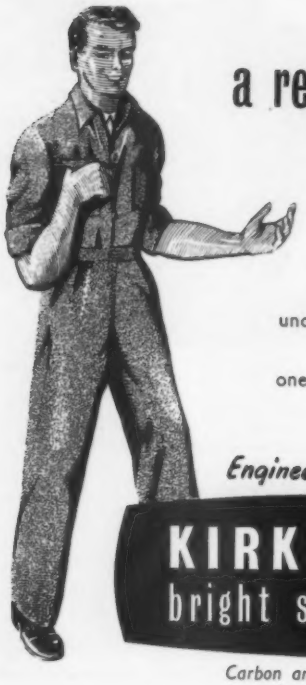
GRINDING CAPACITY 3" dia. x 12" long

SEND FOR DESCRIPTIVE LITERATURE

MYFORD Engineering Co. Ltd.

BEESTON • NOTTINGHAM

Note the price ▶ **£430** (with multi-speed electrics, and revolving spindle workhead. £493-10-0)



a reputation . . .

. . . for consistently sound products, and an uncommonly fine service is one reason why

Engineers prefer

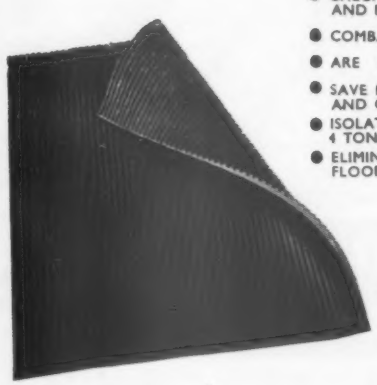
KIRKSTALL
bright steel bars

Carbon and alloy also fully heat treated to engineering specifications

KIRKSTALL FORGE ENGINEERING LTD. LEEDS 5 Tel: Horsforth 2821

VULCASCOT ANTI-VIBRATION PADS
OIL RESISTING

Improve VULCASCOT REG. TRADE MARK *Production!*



- CHECK VIBRATION SHOCK AND NOISE
- COMBAT NERVOUS STRAIN
- ARE EASY TO INSTALL
- SAVE MAINTENANCE TIME AND COST
- ISOLATE LOADS UP TO 4 TONS PER SQ. FT.
- ELIMINATE CUMBERSOME FLOOR FIXINGS

Standard Size
18" x 18" x ⅛"

Manufactured by:

VULCASCOT (Great Britain) LTD.

87-89, ABBEY ROAD, LONDON, N.W.8.

PHONE: MAIDA VALE 7374 & 7375. 'GRAMS: VULCASCOT MAIDA VALE LONDON

200% INCREASE . .

. . IN BRAZING AND SOLDERING SPEEDS!

- DELIVERS FULL HEAT WITH AMPLE RESERVE
- EXCEPTIONALLY LOW RUNNING COSTS
- WATERSPRAY QUENCH FOR HARDENING
- COMFORTABLE WORKING POSITION WITH AMPLE LEG ROOM

THE RADYNE

6kW. INDUCTION HEATER

THE SIMPLEST, FASTEST & MOST RELIABLE EQUIPMENT OF ITS TYPE EVER BUILT
FULL DETAILS FROM

radio heaters ltd., Wokingham, Berks., England.
Phone : Wokingham 1030-1.2 *Grams : Raydyne, Wokingham*

CLAMP YOUR WORK *HYDRAULICALLY!*

This folder shows how to SLASH ASSEMBLY TIMES

NEWTON PRODUCT MARK CLAMP Hydraulic MULTIPOINT

Visit our Stand No. G38, Factory Equipment Exhibition, Earls Court March 28 - April 2.

SEND TODAY for Publication No.243/C

Simple • Inexpensive Instantaneous for

MILLING • GRINDING
WELDING • GLUEING
and every Clamping Problem

POWER JACKS LIMITED
VALETTA RD. · ACTON · LONDON · W.3
TEL: SHEPHERDS BUSH 3443 (6 lines) · GRAMS: HYDRAULIC, EALES, LONDON

A NEWTON PRODUCT

1060

ASSEMBLIES AND
MACHINED COMPONENTS

SPECIAL PURPOSE MACHINES
Design and Manufacture

WELDED FABRICATION
SHEET METAL WORK

PRESS WORK

PATTERN MAKING

ASSEMBLY JIGS & FIXTURES

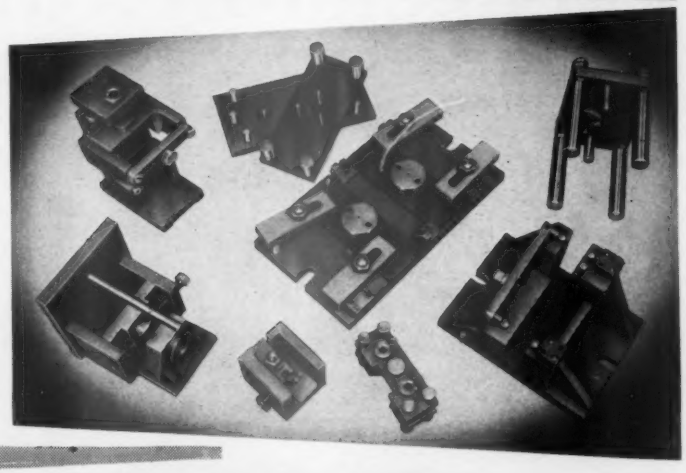
HEAT TREATMENT &
CASE HARDENING

ELECTRO PLATING

PRESSURE DIE CASTING

MACHINE JIGS AND TOOLS
Design and Manufacture

A.I.D. & A.R.B.
APPROVED



AEJ

Aircraft Engineering & Jigs Ltd.

WREN WORKS · CHADDERTON · LANCASHIRE. *Telephone: MAIn (Oldham) 5691*

A vital part of production

Two hands belonging to a skilled worker. Where would the drive for more production be without them? They deserve the best press guards made today. And you have a right to expect that your consideration will not result in a fall in output. The answer is, of course, the "Fastrip" Synchronised Guard for *more* production and *greater* safety.

Send for full details today.

J. P. UDAL

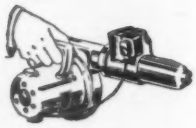
INTERLOCK WORKS, COURT ROAD, BIRMINGHAM, 12.

Telephone: **CALthorpe 3114**

Udal PRESS GUARDS

PREVENT SABOTAGE by Dust and Damp!

Dust and damp can cause serious break downs- particularly in equipment which cannot be brushed out. The answer lies in "Secomak" Portable Electric Blowers- the most powerful obtainable and equally useful as suction cleaners. Model 7 weighs only 10lb. but delivers air at 340 ft. per second. Model 70 weighs 15 lb. and delivers air at 425 ft. per second.



Both models will blow air at temperatures up to 600° F. with the "Secomak" Heater Attachment for drying damp insulation etc.

Write for data sheet 101/P.E.

Secomak

PORTABLE

ELECTRIC BLOWERS

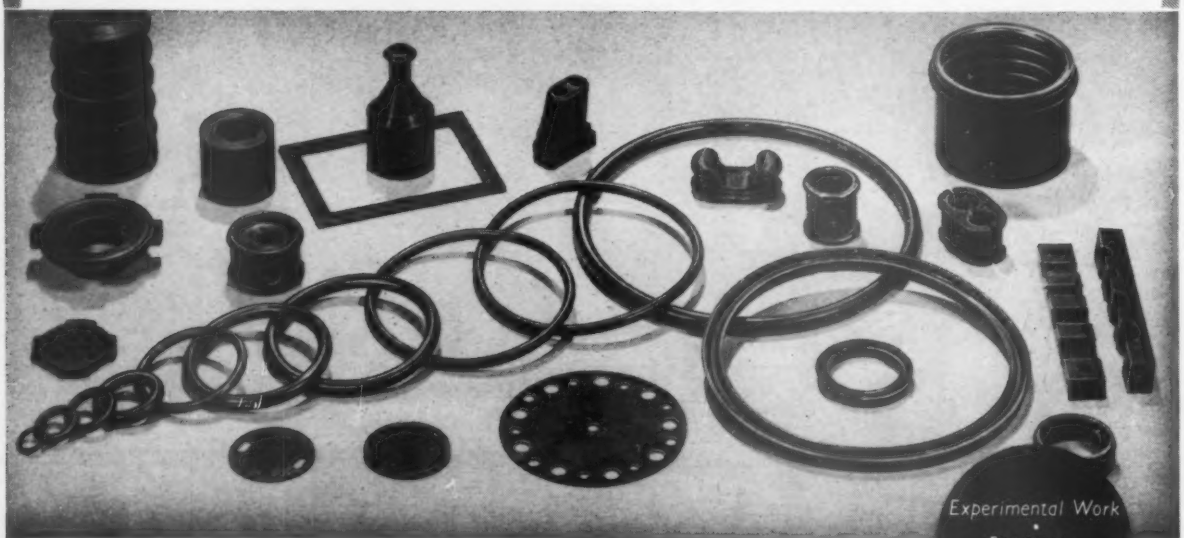
AND SUCTION TOOLS

We also make lightweight stationary units for high velocity suction and blowing suitable for many industrial processes. See data sheets 104, 132, 130 P.E. for full particulars.

SERVICE ELECTRIC CO. LTD.

HONEYPOT LANE · STANMORE · MIDDX. EDGware 5566-9

*PRECISION RUBBERS LTD.



Experimental Work · Prototypes · Bulk Production

***Specialists in Rubber and Synthetic Rubber Mouldings for Industry**

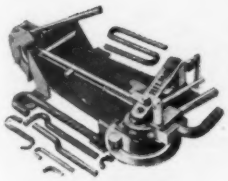
Manufacturers of Rubber Parts for ROLLS-ROYCE LTD.

SEALS · BONDED PARTS · CORD RINGS · DIAPHRAGMS · SILICONE RUBBER COMPONENTS

PRECISION RUBBERS LTD · BAGWORTH · LEICESTERSHIRE · Phone: BAGWORTH 241/2

HILMOR

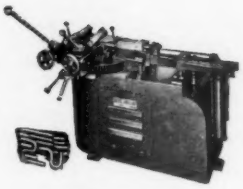
TUBE BENDING MACHINERY



TYPE D.B. 14

Hand-operated Mandrel type benders to produce full bore short radius bends, cold and unfilled in light gauge ferrous tube up to 1⅛" dia. and non-ferrous tube up to 1½" dia. Average production rate 60 bends per hour.

Motorised Mandrel type machines for the long run production of full bore bends on extra short radii. Special tooling can usually be supplied to produce single or the most complex of multiple bends in light gauge tube, cold and unfilled, to conform to the exacting requirements of the aircraft industry.



SERIES "MD"

Send for details to :-

HILMOR LTD (Sales & Service)

CAXTON WAY, STEVENAGE, HERTS.

Made in England Patent No. 661692

We show here "MOVIGRAPH" the latest and most *flexible* visual Chart and Graph system. "MOVIGRAPH" gives more information at less cost and requires less wall space, than any other system—So simple to operate too !

NEW "MOVIGRAPH" panels can now be fitted with Self-Return Flow-lines to your specification.

All parts, including the disappearing flow-lines, guaranteed for three years.

Send for details to :

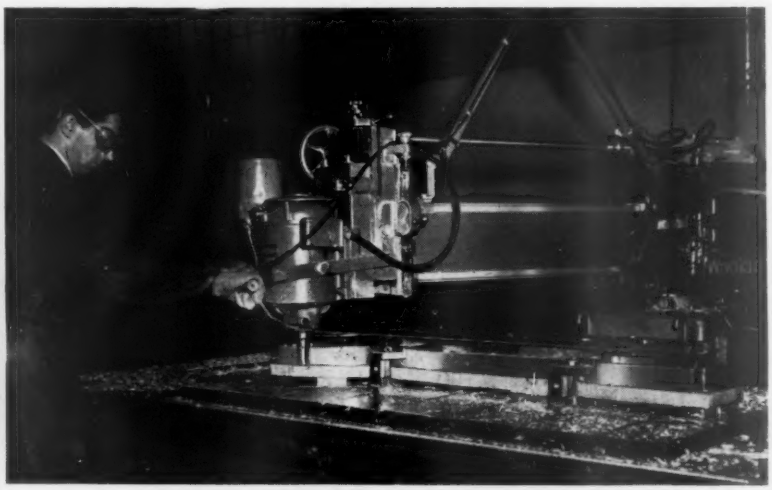
ADAPTA-CHARTS LTD. (Dept. P.E.)

93-94 Chancery Lane, London, W.C.2

Telephone : CHAncery 9354

Suppliers to the Air Ministry, Admiralty, and H.M. Government.

The fastest method of profile milling non-ferrous metals



Photograph by courtesy of Messrs. Vickers-Armstrongs Ltd. Swindon.

If your work calls for milling components out of a solid plate of light alloy it would pay you to learn more about the Wadkin Heavy Duty Router L.Y.R. Although relatively inexpensive this machine will remove a large volume of metal at much faster rates than the orthodox type of milling machines. Not only does this Wadkin reduce actual cutting times but because of cutting speeds up to 18,000 r.p.m., only light clamping is necessary and floor to floor times are considerably reduced.

Why not let us demonstrate the amazing possibilities of the new Wadkin Heavy Duty Router on your own work ?

Wadkin

Telephone: Leicester 67114 *Telephone : MAYfair 7048-9*

Wadkin Ltd., Green Lane Works, Leicester. London Office : 62 Brook Street, W.1.

INDEX TO ADVERTISEMENTS

	Page
Abix Metal Industries, Ltd. ...	LXXVI
Accles & Pollock, Ltd.	—
Accles & Shelvoke, Ltd.	—
Acru Electric Tool Mfg Co., Ltd.	—
Adams Bros. & Burnley, Ltd. ...	—
Adapta-Charts, Ltd.	XCVII
Adcock & Shipley, Ltd.	V
Aircraft Engineering & Jigs, Ltd. ...	XCV
Allen, Edgar & Co., Ltd.	LXXXIII
Alumilite & Alzak, Ltd.	LXXXIX
Archdale, James & Co., Ltd. ...	XLIII
Arrow Electric Switches, Ltd. ...	—
Asquith, William, Ltd.	XXX
Automatic Coil Winder & Electrical Equipment Co., Ltd.	—
Automation, Ltd.	—
Barber & Colman, Ltd.	—
Bawn, W. B. & Co., Ltd.	—
Bedford, John, & Sons, Ltd. ...	XC
Birlec, Ltd.	LVII
Birmingham Aluminium Casting (1930) Co., Ltd.	—
Black & Decker, Ltd.	XXIII
Bratby & Hinchliffe, Ltd.	LXXVIII
Bray Accessories, Ltd.	LXXXVIII
British Aero Components, Ltd. ...	—
British Die Casting & Engineering Co., Ltd.	XL
British Electrical Development Association, The	XLVI
British MonoRail, Ltd.	XXVIII
British Tabulating Machine Co., Ltd.	LXXV
British Thomson-Houston Co., Ltd.	LXI
British Vapour Blast, Ltd.	—
Broadbent, Henry, Ltd.	LXII
Broom & Wade, Ltd.	LXIX
Brown, David, Corporation (Sales) Ltd., The	LII
B.S.A. Tools, Ltd.	XVII
Burton Griffiths & Co., Ltd. ...	XVII
Butterley Co., Ltd., The	—
Catmur Machine Tool Corporation, Ltd.	XCIII
Churchill, Charles & Co., Ltd. ...	—
Churchill Machine Tool Co., Ltd.	—
Cincinnati Milling Machines, Ltd.	III
Climax Rock Drill & Eng. Works Ltd.	IV
Cohen, George, Sons & Co., Ltd. ...	XV
Compoflex Co., Ltd.	—
Cossor, A. C., Ltd.	LI
Coventry Climax Engines, Ltd.	*Outisde Back Cover*
Coventry Gauge & Tool Co., Ltd.	—
Cow, P. B. & Co., Ltd.	LXXIV
Crofts (Engineers), Ltd.	—
Crompton Parkinson, Ltd.	XXXVII
Dawson Bros., Ltd.	LXVIII
Dean Smith & Grace, Ltd. ...	VI
Dowding & Doll, Ltd.	LXIII
Drummond-Asquith (Sales), Ltd. ...	XXXII
Drummond Bros., Ltd.	XXXI
Duckham, Alex. & Co., Ltd. ...	XXII
Dyson & Co., Enfield (1919), Ltd.	XVI
Edibrac, Ltd.	—
Electro-Chemical Eng. Co., Ltd. ...	—
Elgar Machine Tool, Ltd.	—
English Electric Co., Ltd.	—
English Steel Corporation, Ltd. ...	—
Exors of James Mills, Ltd. ...	XXVI
Fawcett, Preston & Co., Ltd. ...	LXVII
Fescol, Ltd.	—
Firth Brown Tools, Ltd.	—
Factory Equipment Exhibition ...	LXXXIX
Firth, Thos., & Brown, John, Ltd.	LXXVII
Fisher & Ludlow, Ltd.	—
Flame Hardeners, Ltd.	XC
Fletcher Miller, Ltd.	LXXX
Fox, Samuel & Co., Ltd.	—
Fractional H.P. Motors, Ltd. ...	—
Fraser, Andrew, & Co., Ltd. ...	LIX
Furnace Brazing Co., Ltd., The ...	VIII
G.P.A. Tools & Gauges, Ltd. ...	XLVIII
Gledhill-Brook Time Recorders, Ltd.	LXXVI
Guest, Keen & Nettlefolds (Midlands), Ltd.	—
Guylee, Frank, & Son, Ltd. ...	LXVIII
Hanovia, Ltd.	—
Harrison, T. S. & Sons, Ltd. ...	—
Harris Tools, John, Ltd.	LXXXII
Herbert, Alfred, Ltd.	XXXIII
Hilger & Watts, Ltd.	LXXXI
Hilmor, Ltd.	XCVII
Holman Bros., Ltd.	—
Hoover, Ltd.	XXXIX
Hordern, Mason & Edwards, Ltd.	XXI
Horstmann Gear Co., Ltd., The ...	LXXX
Howard, Stanley, Ltd.	XX
Hunt, A. H. (Capacitors), Ltd. ...	—
Hymatic Engineering Co., Ltd. ...	XIV
Imperial Smelting Corporation (Sales), Ltd.	—
Impregnated Diamond Products, Ltd.	LIV
Intermit, Ltd.	LXXII
Jessop, Wm. & Sons, Ltd.	LXXIII
Johansson, C. E., Ltd.	LVI
Jones, E. H. (Machine Tools), Ltd. ...	—
Jones, Sidney G., Ltd.	XXVII
Joyce, C. H., Ltd.	LXVI
King, Geo. W., Ltd.	—
Kirkstall Forge Engineering Ltd.	XCIV
Lang, John, & Sons, Ltd.	XXXVI
Lang Pneumatic, Ltd.	—
Lansing Bagnall, Ltd.	XI
Lapointe Machine Tool Co., Ltd.	—
Ley's Malleable Castings Co., Ltd.	—
Leytonstone Jig & Tool Co., Ltd.	XCII
Lloyd, F. H. & Co., Ltd.	LVIII
Lloyd, Richard, Ltd.	LXXVIII
Lund, John, Ltd.	XXIX
Machine Shop Equipment, Ltd. ...	—
Machinery Publishing Co., Ltd. ...	—
Magnesium Elektron, Ltd. ...	XXV
Manganese Bronze & Brass Co., Ltd.	—
Marbaix, Gaston E., Ltd.	LXXXVI, LXXXVII
Marsh Bros., & Co., Ltd.	XCII
Marshall-Richards Machine Co., Ltd.	XII
McGraw-Hill Publishing Co., Ltd.	—
McKechnie Bros., Ltd.	—
Metropolitan-Vickers Electrical Co., Ltd.	X, LV
Midland Iron Co., Ltd., The ...	XXXVIII
Mollart Engineering Co., Ltd., The	LXXII
Monks & Crane, Ltd.	VII
Morris, B.O., Ltd.	—
Myford Engineering Co., Ltd. ...	XCIII
Neill, James, & Co., (Sheffield), Ltd.	—
Newall, A. P., & Co., Ltd. ...	LXX
Newall Group Sales, Ltd. ...	ix, xix, LXV
Newall Group Sales, (Tolimit Gauges), Ltd.	—
Park Gate Iron & Steel Co., Ltd.	*Inside Back Cover*
Parkinson, J., & Son (Shipley), Ltd.	XXXV
Paterson Hughes Engineering Co., Ltd.	XLIV
Pelling & Cross, Ltd.	LXXXVIII
Pilot Works, Ltd.	—
Power Jacks, Ltd.	XCIV
Powers Samas Accounting Machines (Sales), Ltd.	LIII
Precision Grinding, Ltd.	XI II
Precision Rubbers, Ltd.	XCVI
Press Equipment Co.	—
Prestware, Ltd.	—
Projectile & Engineering Co., Ltd.	—
Pryor, Edward, & Son, Ltd. ...	LXXXIV
R. J. H. Tool & Equipment Co., Ltd.	XLI
Radio Heaters, Ltd.	XCIV
Ransomes, Sims & Jefferies, Ltd. ...	—
Ratcliffe, F. S., (Rochdale), Ltd. ...	—
Reavell & Co., Ltd.	LXXXII
Redfern's Rubber Works, Ltd. ...	LXVI
Reliance Gear & Eng. Co., (Salford), Ltd.	XC
Riley, Robert, Ltd.	—
Rockwell Machine Tool Co., Ltd., The	—
Rubert & Co., Ltd.	—
Russell, S., & Sons, Ltd.	LXXXIV
Ryder, Thos. & Son, Ltd.	—
Scrivener, Arthur, Ltd	—
Selson Machine Tool Co., Ltd., The	—
Service Electric Co., Ltd.	XCVI
Shell Mex & B.P., Ltd	XIII
Skinners (Redbridge), Ltd. ...	—
Smart & Brown Machine Tools, Ltd.	—
Snow & Co., Ltd.	—
Sparcatron	LXXIX
Sparklets, Ltd.	LXXIV
Spencer & Halstead, Ltd.	XLVII
Sternol, Ltd.	LXIV
Swift, Geo. & Son, Ltd.	—
Sunbeam Anti-Corrosives, Ltd. ...	—
Sykes, W. E., Ltd.	LXXI
Teleflex Products, Ltd.	—
Thain, Robertson, Ltd.	XCI
Thompson, John, Motor Pressings, Ltd.	LXIV
Town Frederick & Sons, Ltd. ...	L
Turner Machine Tools, Ltd. ...	XCII
Udal, J. P.	XCVI
Unbrako Socket Screw Co., Ltd. ...	XLIX
Universal Tools, Ltd.	LXX
United Steel Companies, Ltd. ...	—
Van Moppes & Sons (Diamond Tools), Ltd.	—
Vulcascot (Great Britain), Ltd. ...	XCIV
Wadkin, Ltd.	XCVII
Ward, H. W., & Co., Ltd. ...	XXXIV
Ward, Thos. W., Ltd.	LXXXV
Wickman, Ltd.	XVIII
Wicksteed, Chas. & Co. (1920), Ltd.	XXIV
Wolverhampton Die Casting Co., Ltd.	XLV
Wild Barfield Electric Furnaces, Ltd.	—
Yale & Towne, Manufacturing Co., Ltd., The	LX
Zinc Alloy Die Casters Association	—

All communications regarding advertisements should be addressed to the Advertising Managers, T. G. Scott & Son, Ltd.
Crown House, 143-147, Regent Street, London, W.1. Phone: Regent 3891.
Printed by Maxwell, Love & Co. Ltd., White Lion Street, London, N.1.

PARK GATE

QUALITY STEELS FOR RAPID MACHINING

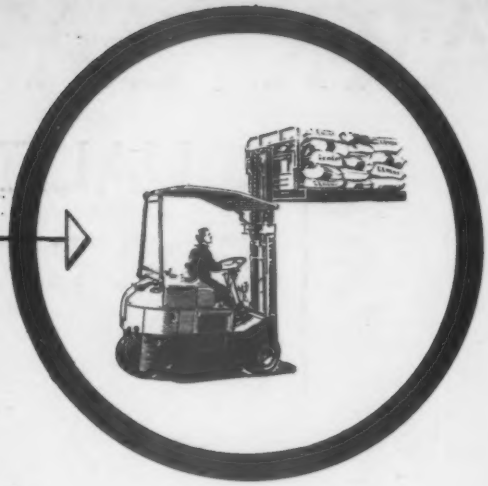
1825 EXPERIENTIA DOCET 1955

special
freecutting
quality bars

THE PARK GATE IRON & STEEL CO. LTD., ROTHERHAM

TELEPHONE: ROTHERHAM 2141 (10 lines) TELEGRAMS: YORKSHIRE, PARKGATE, YORKS

The tools of success



Britain's economic progress over the next generation must come largely from increased productivity; there will not be many extra hands to put to work . . . this means still more mechanical energy must take over from manpower

The prescription for prosperity ● ● ●
is to mechanise handling with the
time-saving, work-saving, space-saving

● ● ● Coventry Climax

- ***fork***
- ***lift***
- ***truck***

COVENTRY CLIMAX ENGINES LTD (Dept JPE) COVENTRY, ENGLAND

J

INST

JOURNAL SUPPLEMENT

Vol. 34, No. 3
MARCH, 1955

INSTITUTION OF PRODUCTION ENGINEERS, 10, CHESTERFIELD ST., LONDON, W.1

SIXTH ANNUAL SUMMER SCHOOL

The Institution's Sixth Annual Summer School will again be held at Ashorne Hill, near Leamington Spa, from Wednesday, 24th August, to Sunday, 29th August, 1955.

The theme of the School will be "**Education for Production Management**".

In order that members of the Institution may be given an early opportunity to enrol, the form overleaf is provided for making provisional bookings. Members who have made provisional bookings will be the first to receive official application forms, together with the programme. The fees for the School will be twelve guineas for non-members and nine guineas for members of the Institution.

CONFERENCE OF STANDARDS ENGINEERS

The British Standards Institution, in co-operation with the Institution of Production Engineers, will arrange, on 4th May, 1955, an informal conference of engineers with special responsibilities for Standards matters.

It is intended that this Conference might be the first of a series of annual meetings for the discussion of problems associated with the application of standards. It is hoped at this first meeting to give particular attention to the possibility of supplementing British Standards by the issue of data sheets in tabular form, in which the essential contents of Standards could be conveniently summarised for direct use in the factory. It is also hoped to consider the question of combining such data sheets with a system of code or reference numbers for each part which could be used for the identification of the parts in factory stores. On both these matters the British Standards Institution will seek the advice of Standards Engineers at the Conference.

It is believed that these informal Conferences will be of help both to the engineers in charge of Standards Departments in industry and to the B.S.I.

Those who wish to attend the Conference should make application to: Dr. E. L. Diamond, The British Standards Institution, British Standards House, 2, Park Street, London, W.1. A registration fee of 10s. 6d. (which includes a buffet luncheon) will be charged to those attending the Conference.

CASE STUDIES IN GOOD MATERIALS HANDLING

The Materials Handling Sub-Committee of the Institution is anxious to publish in the Journal a series of Case Studies describing examples of efficient handling of materials in circumstances which would be of general interest. A number of suitable Case Studies have already been received but more are needed to complete the series. Illustrations will be greatly welcomed as part of the Studies, especially if they can show "before" and "after".

No Case Studies will be published without the prior consent of the firms concerned.

TRAINING OF WORK STUDY OFFICERS

The Annual Conference of The Work Study Society will this year be devoted to "The Training of Work Study Officers". The Conference will take place in Florence Nightingale Hall, University of Nottingham, on 25th/27th March, 1955, and speakers will include representatives of top management, educationalists, and a trade union official. The final sessions will take the form of a discussion led by well-known Work Study authorities and will seek to clarify the requirements for an adequate training.

The Conference fees (including meals and residence) are £3 3s. for members and £4 4s. for non-members. Full particulars may be obtained from the Conference Secretary, Mr. J. Bland, 2, Regent Street, Sherwood Rise, Nottingham.

To: The Secretary,
10, Chesterfield Street,
London, W.1.

1955 SUMMER SCHOOL

PROVISIONAL BOOKINGS

NAME (of individual or firm).....

ADDRESS.....

.....

MEMBERSHIP GRADE.....

Please reserve provisionally ..... places for the above School.

Signature.....

Date.....

HARVARD UNIVERSITY GRADUATE SCHOOL OF BUSINESS ADMINISTRATION

Two Fellowships are available for two years from September, 1955. They are worth approximately £2,000, and the candidate or his employer must provide half this sum. Candidates must be of British nationality, preferably with a University degree, and must have several years' experience in industry. Full details may be obtained from the British Institute of Management, Management House, 8, Hill Street, London, W.1.

FACTORY EQUIPMENT EXHIBITION — WORK STUDY SESSIONS

Two Work Study days are being organised by the British Productivity Council during the Factory Equipment Exhibition at Earl's Court during the week commencing 28th March, 1955. Full particulars of the programme may be obtained from the British Productivity Council, at 21, Tothill Street, London, S.W.1.

CONFERENCE ON JOB METHODS

The London and South East Region of the T.W.I. Association is holding a Conference on Job Methods on 16th March, 1955, at Caxton Hall, London. The central feature of the Conference will be the presentation of the method study training programme for Supervisors in Imperial Chemical Industries, Ltd., followed by group discussion. During the day Mr. H. J. Phillips, of the Ministry of Labour, will tell the Conference something of the revisions being made to the T.W.I. Job Methods Programme.

The Conference fee, inclusive of refreshments, will be 10s. 6d.

Members of the Institution of Production Engineers will be welcomed at the Conference, but in order that the discussion groups should not become too unwieldy, early application is advised, to Mr. J. V. Ellis, Hon. Secretary, 18, Rossall Crescent, London, N.W.10.

MEETINGS

Visitors' tickets may be obtained from Section Honorary Secretaries.

MARCH, 1955

BIRMINGHAM **7 p.m. MARCH 16th**
The James Watt Memorial Institute, Great Charles Street, Birmingham 3.
Annual General Meeting and Film Show.

BIRMINGHAM GRADUATE **6.30 p.m. MARCH 8th**
The James Watt Memorial Institute, Great Charles Street, Birmingham 3.
Annual General Meeting and Lecture on "The Use of Air Operated Fixtures in Mass Production" by J. F. Smith, A.M.I.Mech.E., A.M.I.Prod.E.

BIRMINGHAM GRADUATE **MARCH 5th**
Works Visit to Round Oak Steel Works, Ltd.

COVENTRY **7 p.m. MARCH 29th**
The Craven Arms, High Street, Coventry.
Annual General Meeting followed by a film evening. "Die Casting — How Else Would You Make It?" "Gauge Block", by C. E. Johansson, Ltd.

COVENTRY GRADUATE **MARCH 16th**
Hare and Squirrel Hotel, Cow Lane, Coventry.
Douglas D. Davis Award.

COVENTRY GRADUATE **MARCH 10th**
Visit to Vauxhall Motor Works.

CORNWALL **7.15 p.m. MARCH 17th**
The Cornwall Technical College, Trevenson, Pool, Redruth.
"The Effective Use of Material", by F. Nixon, B.Sc.(Hons.), M.I.Mech.E., F.R.Ae.S.

DERBY **7 p.m. MARCH 14th**
College of Art, Green Lane, Derby.
Annual General Meeting, followed by films.

DONCASTER **7 p.m. MARCH 8th**
The Danum Hotel, Doncaster.
"Applications of Rubber to Engineering", by J. P. Holdsworth, B.Sc.(Eng.), G.I.Mech.E.

EASTERN COUNTIES **7 p.m. MARCH 11th**
The Diocesan Hall, Tower Street, Ipswich.
Three short Papers: "Planning an Electrical Installation for a Factory", by W. Gilbert, M.I.E.E.; "Quality Control in the Foundry", by A. H. Horton and C. N. Jennings; "Flaw Detection", by E. J. Cove. To be preceded by Annual General Meeting.

EDINBURGH **7.30 p.m. MARCH 16th**
Chamber of Commerce Rooms, 25 Charlotte Square, Edinburgh.
"Aircraft Catapults", by Cmdr. C. C. Mitchell, O.B.E., R.N.V.R., B.Sc., M.I.Mech.E., followed by the Annual General Meeting.

GLASGOW **7.30 p.m. MARCH 3rd**
The Institute of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow, C.2.
Annual General Meeting followed by Open Discussion on "Die Castings" led by A. Henderson and J. W. Burrows.

GLASGOW **7.30 p.m. MARCH 17th**
The Institute of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow, C.2.
"The Control of Quality in Medium Quantity Production", by J. Loxham, M.I.Mech.E., M.I.Prod.E., F.R.S.A.

GLOUCESTER & DISTRICT **7.15 p.m. MARCH 2nd**
The Cheltenham Motor Club, High Street, Cheltenham, Gloucestershire.
"Modern Methods of Production Control", by E. J. Thomas, A.M.I.Prod.E. Joint meeting with the North Gloucestershire Group of the Institute of Cost and Works Accountants.

GLOUCESTER & DISTRICT **7.15 p.m. MARCH 24th**
Annual General Meeting held at Dowty Equipment Ltd., Cheltenham.

HALIFAX **7 p.m. MARCH 2nd**
The White Swan Hotel, Halifax.
"Work Measurement Research", by Prof. T. U. Matthew, Ph.D., M.Sc., Wh.Sch., A.M.I.Mech.E., M.I.Prod.E., A.R.T.C., M.I.Chem.E., M.S.I.E., preceded by the Annual General Meeting.

HALIFAX **7.15 p.m. MARCH 14th**
Regional Meeting—see Sheffield.

HALIFAX **7 p.m. MARCH 25th**
The George Hotel, Huddersfield.
Dinner and Dance. 7 p.m. for 7.30 p.m.

HALIFAX GRADUATE **7.15 p.m. MARCH 2nd**
The White Swan Hotel, Halifax.
"Work Measurement Research", by Prof. T. U. Matthew, Ph.D., M.Sc., Wh.Sch., A.M.I.Mech.E., M.I.Prod.E., A.R.T.C., M.I.Chem.E., M.S.I.E. Joint Meeting with Halifax Senior Section.

LEICESTER **7 p.m. MARCH 10th**
Balmoral Room, Bell Hotel, Leicester.
"The Measure of Progress", by F. G. S. English, M.I.Prod.E.

LINCOLN **7.30 p.m. MARCH 24th**
The Ruston Club, Unity Square, Lincoln.
Annual General Meeting—followed by films relating to transfer machines.

LIVERPOOL **MARCH 5th**
Rowton Hall, Chester.
Annual Dinner.

LIVERPOOL **7.30 p.m. MARCH 16th**
Exchange Hotel, Liverpool.
"Electronics as an Aid to Production", by Dr. H. A. Thomas.

LIVERPOOL **7.30 p.m. MARCH 30th**
Exchange Hotel, Liverpool.
Annual General Meeting.

LIVERPOOL GRADUATE **7.30 p.m. MARCH 18th**
The Stork Hotel, Liverpool.
Annual General Meeting and film evening. "The Moving Spirit"; "Making the Rocket"; "Mediterranean/Cape Rally, 1953".

LONDON **7 p.m. MARCH 24th**
The Royal Empire Society, (Craven Street entrance,) Strand, London, W.C.2.
"Research and Development of Production Techniques", by Dr. D. F. Galloway, Wh.Sch., B.Sc.(Hons.), M.I.Mech.E., M.I.Prod.E., M.I.I.A., A.M.I.E.E., M.Inst.Pet., followed by the Annual General Meeting.

LONDON **7 p.m. MARCH 31st**
The Old Ship Hotel, Brighton, 1.
"The Measurement of Surface Finish", by S. F. Smith.

LONDON GRADUATE **MARCH 5th**
Works Visit to The National College of Horology, St. John's Street, London, E.C.1.
Demonstration of modern machines and equipment for instrument and watch making.

LONDON GRADUATE **7.15 p.m. MARCH 22nd**
The Institution of Production Engineers, 10 Chesterfield Street, London, W.1.
"Predetermined Time Standards", by J. E. Payne.

LUTON **7.15 p.m. MARCH 29th**
The Small Assembly Room, Town Hall, Luton.
"Management and Production", by B. M. Sixsmith, M.A.

LUTON GRADUATE **7.45 p.m. MARCH 10th**
The Lecture Hall, Central Library, George Street, Luton.
Annual General Meeting and film "Powered Flight—The Story of the Century" (loaned by courtesy of Shell-Mex and B.P. Ltd.).

LUTON GRADUATE **2.15 p.m.—6 p.m. MARCH 23rd**
Works Visit to Wild-Barfield Electric Furnaces, Ltd., Elecfurn Works, Watford By-Pass, Watford, Herts.
The visit will consist of a tour of Research and Development Departments in addition to the Works, to be followed by a discussion.

MANCHESTER **7.15 p.m. MARCH 21st**
Reynolds Hall, (Room C.3), College of Technology, Sackville Street, Manchester, 1.
"Manufacture of Commercial Vehicles", by A. Hosker.

MANCHESTER GRADUATE 6.45 p.m. **MARCH 2nd**
Reynolds Hall, College of Technology, Sackville Street, Manchester, 1.
Annual General Meeting followed by a film show. Members' ladies are invited.

MANCHESTER GRADUATE 8 p.m. **MARCH 22nd**
Works Visit to "The Manchester Guardian", Cross Street, Manchester.

NORTH EASTERN 7 p.m. **MARCH 21st**
Neville Hall, Newcastle-on-Tyne.
Brains Trust Evening. *Panel*:- W. D. Opher, M.I.Mech.E., M.I.Prod.E.; W. Scott, O.B.E., J.P., M.I.Mech.E., M.I.Prod.E.; J. E. Fogg, M.I.Prod.E.; A. E. Cameron, M.I.Prod.E.

NORTH EASTERN GRADUATE 7 p.m. **MARCH 11th**
Roadway House, 8 Oxford Street, Newcastle-on-Tyne.
"Plastic Moulding", by R. J. Lester.

NORTH EASTERN GRADUATE **MARCH 19th**
Works Visit to Steels Engineering Products, Ltd., Pallion, Sunderland.

NORWICH 7 p.m. **MARCH 16th**
The Assembly House, Theatre Street, Norwich.
Annual General Meeting and film show. Visitors are invited to attend the film show which will commence at 8 p.m.

NORTHERN IRELAND 7.30 p.m. **MARCH 10th**
The Kensington Hotel, Belfast.
Annual General Meeting and Informal Brains Trust.

NOTTINGHAM 7 p.m. **MARCH 2nd**
Victoria Station Hotel, Milton Street, Nottingham.
Annual General Meeting followed by films of interest to Production Engineers.

OXFORD 7.15 p.m. **MARCH 8th**
The Town Hall, Oxford.
"High Frequency Heating and Brazing", by E. V. Beatson.

OXFORD 7.15 p.m. **MARCH 22nd**
Morris Motors, Ltd., Hollow Way, Cowley, Oxford.
Annual General Meeting, followed by a film show.

PETERBOROUGH 7.15 p.m. **MARCH 8th**
The Campbell Hotel, Bridge Street, Peterborough.
Annual General Meeting (Members only), followed by a film show at 8 p.m. "21st Monte Carlo Rally"; "The Tube Age"; "Steel Pipes for Sindri"; "Highlights of Farnborough, 1952".

PRESTON 7 p.m. **MARCH 9th**
The Crown Hotel, Market Place, Blackburn.
Annual General Meeting and "The Selection and Training of Engineering Apprentices", by E. K. Langham.

READING 7.30 p.m. **MARCH 10th**
The Great Western Hotel, Reading.
"Industrial Law", by H. P. Jost, A.M.I.Mech.E., A.M.I.Prod.E., Mem.A.S.M.E. The lecture will be preceded by the 6th Annual General Meeting.

ROCHESTER 7.30 p.m. **MARCH 10th**
Sun Hotel, Chatham.
"The Layout and Machinery Required for the Production of Clothing", by W. Bland.

SHEFFIELD 6.30 p.m. **MARCH 14th**
The Grand Hotel, Sheffield. Regional Meeting.
"The Practical Application of Production Engineering Research", by Dr. D. F. Galloway, Ph.D., Wh.Sch., B.Sc.(Hons.), M.I.Mech.E., M.I.Prod.E., M.I.I.A., A.M.I.E.E., M.Inst.Pet., preceded by the Annual General Meeting at 6.15 p.m. (Sheffield Section).

SHEFFIELD GRADUATE 6.30 p.m. **MARCH 28th**
The Royal Victoria Station Hotel.
Graduate Award Paper, followed by film evening and Annual General Meeting.

SHREWSBURY 6.45 p.m. **MARCH 30th**
Shrewsbury Technical College, Shrewsbury.
Annual General Meeting, followed by a film programme at 7.45 p.m.

SOUTHERN 8 p.m. **MARCH 4th**
Polygon Hotel, Southampton.
Annual General Meeting.

SOUTHERN 7.15 p.m. **MARCH 16th**
Polygon Hotel, Southampton.
"Some Problems Associated with the Manufacture of Large Steam Turbo-Alternators", by J. Henderson, A.M.I.Prod.E., A.M.I.Mech.E., and J. W. Taylor, Assoc.I.E.E., A.M.I.Prod.E.

SOUTHERN 7.30 p.m. **MARCH 23rd**
Polygon Hotel, Southampton.
4th Annual Dinner Dance

SOUTH ESSEX 7.30 p.m. **MARCH 16th**
Ilford Bowling Club, near Ilford Station, Ilford.
Annual General Meeting and films: "The Fawley Achievement"; "Rigg 20"; "The Mille Miglia, 1953".

SOUTH WALES & MONMOUTHSHIRE 7 p.m. **MARCH 31st**
The South Wales Institute of Engineers, Park Place, Cardiff.
"Economics in Production Engineering", by Dr. F. A. Wells, B.Sc., Ph.D. Joint Lecture meeting with the Institute of Cost and Works Accountants.

STOKE-ON-TRENT 7 p.m. **MARCH 18th**
The Town Hall, Hanley, Stoke-on-Trent.
"Management and Production", by B. M. Sixsmith, M.A., commencing at 7.45 p.m. Joint lecture with the British Pottery Managers and Officials Association. The Annual General Meeting (Members only), commences at 7 p.m.

WESTERN 7.15 p.m. **MARCH 23rd**
Beaufort Room, Grand Hotel, Broad Street, Bristol, 1.
"Motor Car Manufacture at Vauxhall Motors Ltd.", by R. L. Blades.

WESTERN GRADUATE 7.30 p.m. **MARCH 14th**
The Grand Hotel, Broad Street, Bristol, 1.
Annual General Meeting, followed by a film show.

WEST WALES 7.30 p.m. **MARCH 18th**
The Central Library, Alexandra Road, Swansea.
"Work Measurement", by J. A. Lamond, M.I.C.E., M.I.Mech.E., M.I.E.E.

WOLVERHAMPTON 6.45 p.m. **MARCH 2nd**
Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.
Annual General Meeeting to be followed by a demonstration and talk on "The Applications of Radioactive Isotopes",

WOLVERHAMPTON GRADUATE
by F. Scott, B.Sc., A.R.I.C.
7.30 p.m. **MARCH 23rd**
Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.
"Ferrous Die Casting", by H. E. Redshaw. Preceded by the 11th Annual General Meeting at 7 p.m.

WOLVERHAMPTON GRADUATE 9 a.m. **MARCH 19th**
Works Visit to Wickman Ltd., Coventry.

WORCESTER 7.30 p.m. **MARCH 23rd**
The Cadena Cafe, Worcester.
"The Development and Application of Tungsten Carbide Tools", by permission of Wickman Ltd.

YORKSHIRE 7 p.m. **MARCH 7th**
The Hotel Metropole, Leeds.
Annual General Meeting and lecture on "The History of Radar", by C. O. Taylor, M.B.E.

YORKSHIRE 6.30 p.m. **MARCH 14th**
The Grand Hotel, Sheffield.
"The Practical Application of Production Engineering Research", by Dr. D. F. Galloway, Ph.D., Wh.Sch., B.Sc.(Hons.), M.I.Mech.E., M.I.Prod.E., M.I.I.A., A.M.I.E.E., M.Inst.Pet. Regional Meeting.

APRIL MEETINGS

HALIFAX GRADUATE 7.30 p.m. **APRIL 6th**
The White Swan Hotel, Crown Street, Halifax.
"The Production of Modern Electric Washing Machines", by J. Senior, A.M.I.Prod.E.

LONDON GRADUATE 7.15 p.m. **APRIL 5th**
The Institution of Production Engineers, 10 Chesterfield Street, London, W.1.
Annual General Meeting and Film Evening.

LIVERPOOL GRADUATE 7.45 p.m. **APRIL 5th**
The Stork Hotel, Liverpool.
"Planning an Archaeological Excavation", by J. H. Iliffe. (Director, City of Liverpool Public Museums).

WOLVERHAMPTON **APRIL 6th**
Stafford.
"Organisation for Production", by B. F. Stokes, A.M.I.Prod.E.

PRODUCTION APPOINTMENTS

BULLETIN No. 54
MARCH 1955

This bulletin is circulated to all members of the Institution monthly as near as possible to the first of the month. Firms or organisations wishing to insert notices in the bulletin should communicate with the Secretary at 10, Chesterfield Street, London, W.1.

The last date for receiving material for insertion in the following month's bulletin is the 20th of each month.
The fee for insertion of particulars regarding each appointment is £3 3s. (up to 100 words), and over 100 words £5 5s. No charge is made to firms affiliated to the Institution, Technical Colleges, Universities and similar organisations.
Advertisers are advised that better response is likely if, in addition to essential qualifications, the following information is given:-
(*a*) Location of appointment; (*b*) Status in the organisation and scope of promotion; (*c*) Salary range and age range.
Advertisers are asked to advise the Institution when vacant appointments are filled. The Institution reserves the right to refuse or withdraw any announcement and also to make any alteration in the wording to ensure conformity with Institution standards.
Members interested in the following appointments should make application in accordance with the terms of notice. No correspondence can be undertaken by the Secretary other than the forwarding of replies to Box *Nos.*

Planning and Estimating Engineer required by rapidly expanding engineering company manufacturing own specialised products in Sussex. Write stating full technical and practical training experience to: Box No. 1024, I.Prod.E., 10 Chesterfield Street, London, W.1.

Assistant Production Engineers. Dowty Hydraulic Units Ltd., Ashchurch, near Tewkesbury, invite applications for positions as Assistant Production Engineers from Graduates and Associate Members of not more than 35 years of age. The organisation is an expanding one and has an interesting and varied programme of new projects The vacancies are permanent and progressive and offer considerable scope to the right men. Applications should be addressed to: the Personnel Manager and should state previous training, experience and present salary.

Senior Work Study Engineers are required by the English Electric Company Limited at Stafford, for product and manufacturing development in the following product groups:— heavy electrical machines; high voltage switchgear; instruments, meters and relays. Applications are invited from engineers with a sound background of practical engineering in a manufacturing industry, together with technical qualifications to at least O.N.C. level. Please write, quoting Ref. 1225D, to: Dept. C.P.S., 336/7, Strand, London, W.C.2.

Senior Planning Engineer to take charge of planning section engaged on armament work. Should be conversant with processing, scheduling, ratefixing and shop loading of machine, fitting and assembly shop work. Liaison with sub-contractors, Ministry and Service personnel will be necessary. Senior staff appointment with comprehensive pension schemes. Apply, giving details of experience, etc., to: Personnel Manager, The Bristol Aeroplane Company Limited, Aircraft Division (Weston Factory), Oldmixon, Weston-Super-Mare.

Works Manager is required by light engineering company in Birmingham engaged on small batch production, employing 180 persons. Applicant should have good shop floor experience of machine tools, and ability to organise machine shop, assembly and finishing departments. The position will entail the direction of detailed work of departments through the various Foremen, the improvement of methods in conjunction with production engineer, the meeting of production programmes and the maintenance of discipline in the works. Salary £1,500 per annum with pension scheme. Reply, stating age, education and previous experience in confidence to: Box No. 1011, I.Prod.E., 10 Chesterfield Street, London, W.1.

Management Consultancy. Leading Group, continuing to expand its activities, seeks additional staff for its consultancy practice. Applications invited from executives possessing a wide experience of industrial organisation, methods and layout in either engineering or process industries. Excellent prospects and adequate remuneration offered to suitable men not exceeding the age of 45. Please send full details and indication of salary requirements to: Box No. 111, R. Anderson (Advertising) Co., 14 William IV Street, W.C.2.

Management Consultancy. A well-known company is prepared to train a limited number of suitable applicants for ultimate appointments as executives in management consultancy. Applications are invited from men between the ages of 25 and 30 years who wish to take up a career in consultancy. They must be university graduates in economics or engineering, preferably with some industrial or commercial experience; willing to travel home and overseas. Salary paid during training appropriate to qualifications and experience. Please send details and indications of present salary level, in confidence to: Box No. 106, R. Anderson & Co., 14 William IV Street, London, W.C.2.

Chief Ratefixer (Production Machine Shop). Applications are invited for the above position which is an executive appointment covering general machine shop ratefixing. Candidates must be thoroughly experienced in general machine shop practice and be fully conversant with modern work study methods. This is a position of responsibility in a progressive company. Pension scheme, assistance with housing and removal expenses. Apply in writing, giving full details of previous experience, technical qualifications, etc., and quoting reference P9 to: Personnel Manager, P.O. Box No. 241, Belfast.

Work Study Engineers. Henry Wiggin & Co. Ltd., Wiggin Street, Birmingham 16, manufacturers of nickel alloys, wish to engage staff for their work study department, to replace members who have been promoted. Applicants must be really first-class work study engineers having (a) a sound education; (b) not less than 5 years' experience of work study and the practical application of payment by results to production and maintenance service departments; (c) a personality suitable for this type of work. The appointments offer wide scope and will be limited to keen and progressive men. A very good salary commensurate with the experience and high standard required will be paid. A non-contributory pension scheme is in operation. Apply, in writing to: the Managing Director, giving full details of past experience and employers, education and qualifications.

Engineer required for medium engineering concern in Leeds area. Sound basic knowledge of machine shop methods and supervision, and able to assess a proper value where process-times are concerned. Age no bar to an energetic and experienced man, used to putting in works hours in interests of production. Salary £800 per annum. Write, stating age, and giving fullest details of experience, particularly in regard to any responsibility for, and results regarding output. Box No. 1027, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Engineer to take charge of department of 15 in South of England factory on high grade mechanical engineering work. Only men experienced in batch quantity manufacture and conversant with payment by results techniques need apply. Salary according to ability. Send full details in confidence to: Box No. 1028, I.Prod.E., 10 Chesterfield Street, London, W.1.

Methods Engineer required with previous experience of layouts for machine shop, assembly lines and test area on mass production of small electro-mechanical engineering equipment. Applicants should be capable of assessing prototype units and revising designs for the most economic production, planning and tool design. They should be able to produce revised cost figures of project covering material, labour, tool and plant for presentation to works management. London area. Please reply, giving full details of experience to: Box No. 1029, I.Prod.E., 10 Chesterfield Street, London, W.1.

Works Manager required for factory employing 700 engaged on production of electronic equipment, radio components, etc. Must be experienced in flow production techniques for machine and assembly operations, and able to undertake the preparation of factory layouts for this class of work. Experience is also essential in selecting, engaging and training labour and in handling labour negotiations. This is an opportunity for a man of drive and initiative, who is acutely cost-conscious, to join an old-established company expanding its ranges of products. Salary £1,500/1,700 per annum, depending on experience and qualifications. There is a staff pension scheme in operation. Write, giving full personal details in confidence to: Secretary, The Edison Swan Electric Co. Ltd., 155 Charing Cross Road, London, W.C.2.

Machine Tool Draughtsman—Ordinary National Certificate standard. Interesting work on hydraulically operated surface grinding machines with excellent opportunity for advancement. A.E.S.D. rates or better. Particulars in writing to: Snow & Co. Ltd., Sheffield 3.

Assistant Machine Tool Engineer required by The English Electric Company initially at Luton, later at Stevenage. The successful applicant, who will be responsible for the selection and procurement of the most suitable machine tools and the maintaining of adequate records should have served an engineering apprenticeship, and preferably hold the Ordinary National Certificate. Housing assistance can be given to the successful applicant normally resident in the Greater London area. Applications to: Dept. C.P.S., 336/7 Strand, London, W.C.2, quoting Ref. No. 1120H.

Estimator. First-class man, capable of preparing technical drawing estimates for multi spindle automatics, required by leading Midland machine tool manufacturers. Applicants should possess sound knowledge of modern tooling methods, supported by a good practical background. Applications addressed to: the Personnel Manager, should state full particulars of career to date, age and an indication of salary required. Box No. 1030, I.Prod.E., 10 Chesterfield Street, London, W.1.

Engineers and Designers. Large and expanding company with world wide connections, which makes extensive use of highly mechanised production equipment and has modern well-equipped engineering resources, requires trained engineers and designers who can make a constructive contribution to improved production methods. Wide scope and opportunity. Salaries commensurate with ability. Write, Ref. ED/1, Box 3W P.1589, A. K. Advertising, 212a Shaftesbury Avenue, London, W.C.2.

Qualified Engineer with sheet metal experience required to act as Assistant to Managing Director of sheet metal engineering works in London district. Applicant should have had some sales experience, have had a good education, possess personality and come within an age group of 35/40 years. Salary £1,500/£2,000 according to qualifications and experience. Pension scheme. Apply with full particulars to: Box No. 1031, I.Prod.E., 10 Chesterfield Street, London, W.1.

Design Draughtsmen required with experience on either general machine design, sheet metal work, or jig and tool design. The work is varied and interesting and men with initiative and sound technical training are required. Apply, giving details of age, experience and training to: Chief Design Engineer, The Chatwood Safe & Engineering Co. Ltd., Shrewsbury.

Engineer (aged 23 - 35 years) having a degree or Higher National Certificate, is required for a permanent appointment on work concerned with research and development of engineering production processes. The work is varied and interesting and may include liaison with engineering firms throughout the country. For an engineer with initiative and personality there is considerable scope for advancement. The position is superannuated and carries a good commencing salary. Send full details, including age, experience, qualifications and present salary, in confidence to: Box No. 1033, I.Prod.E., 10 Chesterfield Street, London, W.1.

Time Study Engineer required for the quantity production of C.I. engines. Preferred minimum qualifications: O.N.C., full apprenticeship and experience in the automobile industry. Please apply, stating age, experience (in full chronological order) and salary required to: Personnel Manager, F. Perkins Ltd., Diesel Engine Manufacturers, Peterborough.

Production Engineer required by heavy electrical engineering company in the London area to take charge of methods department and small jig and tool drawing office. Applicants must have served an indentured apprenticeship and passed the Higher National Certificate in mechanical or production engineering, or possess an engineering degree with post graduate factory training. Subsequent experience in work study, wage incentives and jig and tool design essential. The post demands a person with drive, initiative and enthusiasm combined with sound practical engineering knowledge. Salary commensurate with experience. Pension scheme. Age 30 - 35. Applications in writing to: Box No. 1034, I.Prod.E., 10 Chesterfield Street, London, W 1.

Industrial Engineering Consultant. Vacancies exist for men of outstanding ability, enterprise and experience as Industrial Engineering and Management Consultants. The commencing salary will be attractive to men with the right qualifications. Appointments will be pensionable and there are excellent prospects for advancement. Successful applicants will receive training. Candidates should have a university degree in engineering or comparable qualifications; sound appreciation of the economics of industrial problems; already hold a senior executive appointment at a four figure salary in a large or medium sized industrial organisation, preferably in engineering or allied trades; and be between 32 and 45 years of age. They should have personal experience of production engineering functions, including work study, process planning, factory layout and materials handling techniques, and a sound working knowledge of cost control and production control. Applications in writing, supported by full personal and professional particulars should be addressed in confidence to: the Secretary, C. G. Chantrill & Partners Ltd., National House, 14 Moorgate, London, E.C.2.

Planning Engineer required for medium size engineering works in West London area. Applicants should have had previous experience of process planning, especially of machine shop work, jig and tool design and ratefixing or work study. Experience of process planning of welding work would be of advantage. A high standard of ability and initiative is necessary. Age limit 25 - 35. Preference will be given to applicants who have served full apprenticeship and have Higher National Certificate in mechanical engineering. Apply, stating age, education, qualifications, previous posts held and present salary, to: Box No. 1035, I.Prod.E., 10 Chesterfield Street, London, W.1.

Production Manager required for medium size engineering works in West London area. Applicants should have knowledge and experience of modern welding, fabrication and machine shop production methods and must possess

initiative, drive and powers of leadership. Previous factory management experience is essential and preference will be given to those with suitable professional qualifications. Staff Pension Scheme. Age limit 30 to 40. Apply, stating age, education, qualifications, posts held and present salary to: Box No. 1036, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Engineer required by Button Manufacturers. Work Study experience on light engineering desirable. Staff appointment to develop department. Apply in confidence, stating age and salary required, with full details of experience to: Ernest & Henry Limited, St. Helen's Auckland, Bishop Auckland, Co. Durham.

Works Manager required for old-established medium sized engineering company. The works comprise foundry, machine shop, plate and erection shops for the manufacture of medium-heavy engineering products. Applicants must have had first-class executive and production experience in this type of work, including control of outside erection staff. Age limits are preferably 35 - 45, and the post will command an adequate four figure salary commensurate with the qualifications of the successful applicant. Full particulars, which will be held in strict confidence, should be sent to: Box No. 1037, I.Prod.E., 10 Chesterfield Street, London, W.1.

Methods Engineer. Sentinel (Shrewsbury) Limited, Shrewsbury, require a Methods Engineer with practical experience of shop layout and materials handling in the engineering industry. The post carries an attractive salary and a pension scheme is in operation. Applications, which will be treated in confidence, should be addressed to: the Personnel Manager, giving qualifications and positions held in chronological order.

Production Control Superintendent required by leading aircraft company on South Coast. Previous similar experience essential. Staff assurance and pension fund. Write, stating age, details of previous and present employment and salary expected, in confidence, to: Box No. 1038, I.Prod.E., 10 Chesterfield Street, London, W.1.

Work Study Engineer required to assist in introduction of work study into large engineering works in Slough area. Applicants age 25/35 should have some experience of method study and work measurement techniques. Experience of press work an added advantage. Salary according to experience but in the range of £600/£800. The post is a staff appointment and holds excellent prospects for advancement. Pension and profit sharing schemes after 12 months. Write in confidence, stating age, education, experience and present salary to: Personnel Manager, Box No. 1039, I.Prod.E., 10 Chesterfield Street, London, W.1.

Time and Motion Study. A young man, preferably 23 - 25 years, is required for Time and Motion Study. The most essential qualities required are outstanding personality and sound machine shop experience. Previous experience of Time Study is not essential as training will be given to a man possessing the correct basic qualities. This is a new post made necessary due to expansion and offers excellent prospects for the successful applicant. Apply to: Clarkson (Engineers) Ltd., Nuneaton.

Workshop Superintendent. Applications are invited for appointment as workshop superintendent to an engineering company engaged in the manufacture of chemical plant, including steel and non-ferrous fabrication, together with associated pumping and compressing equipment. The post will entail responsibility for the organisation and direction of the production workshops and associated planning sections, and calls for proved administrative ability together with an expert knowledge of production methods and techniques. Applicants should be qualified engineers with management experience. Applications giving full information regarding experience, qualifications, age and present salary to: Box No. 1040, I.Prod.E., 10 Chesterfield Street, London, W.1.

Qualified Engineer, possessing imagination, original thought and a flair for experimental and investigational work on packaging machinery required to take charge of engineering development department of rapidly expanding group of companies, with world-wide interests in the pharmaceutical and packaging industries. This is a senior appointment and salary will be commensurate. Own staff advised of vacancy. Please apply to: Box AC, Samson Clarks, 57/61 Mortimer Street, London, W.1.

Works or Maintenance Engineers required for factory in Sunderland. Must have had experience in installation and operation of factory services, including heating, ventilation, water, gas and electricity supply; maintenance of machine tools and appliances used for light mass production work and drawing office experience in mechanical design. Ability to control office and works staff is necessary. Salary £750/£900 per annum. Apply: Personnel Superintendent, The Edison Swan Electric Co. Ltd., Cosmos Works, Brimsdown, Enfield, Middlesex.

Production Planning Engineer required for factory in Enfield. Should have had experience, preferably but not essentially in electronic valve production. Must be able to break down programmes into component part requirements and raw materials and organise supplies. Also must be able to assess plant capacities and organise loading in economic quantities. Knowledge of ratefixing and incentive schemes essential. Salary £900/£1,000 per annum. Apply: Personnel Superintendent, The Edison Swan Electric Co. Ltd., Cosmos Works, Brimsdown, Enfield, Middlesex.

Assistant Production Controller required by light engineering company specialising in instrument manufacture, South West Middlesex area. Previous experience of production control, including progress and assembly shop loading is essential. Please write, stating details of previous experience, age and salary required to: Personnel Manager, Box No. 1041, I.Prod.E., 10 Chesterfield Street, London, W.1.

Experienced Work Study Engineer. A. Boake, Roberts & Co. Ltd., makers of chemicals and plasticisers, require an experienced work study engineer. Must be able to carry out method investigations, introduce incentive schemes and labour control systems for indirect workers. Salary dependent on age and experience, but of the order of £800/£1000 per annum. Replies should be addressed to: the Managing Director, A. Boake, Roberts & Co. Ltd., Carpenters Road, London, E.15.

A Senior Methods Engineer is required for a consulting service in engineering and other production methods improvement work. Good engineering qualifications and experience in shop practice and mechanical handling work are necessary. This post offers an exceptional opportunity for a wide variety of work in connection with up-to-date developments in methods, and short visits abroad may be required occasionally. Salary £1200 with further prospects. Please reply, with full details to: Box No. BS 1042, I.Prod.E., 10 Chesterfield Street, London, W.1.

A Senior Draughtsman is required as Section Leader in the drawing office for the consulting service described in the advertisement above. Good experience of the latest practice in design of jigs and fixtures, tools, cams, press and moulding tools is necessary, together with sound machine shop practice. There is a very interesting opportunity for keeping in contact with the most modern developments in tooling design both at home and abroad. Salary £1000 with further prospects. Please reply, with full details, to: Box No. BS 1043, I.Prod.E., 10 Chesterfield Street, London, W.1.

General Manager. William Mallinson & Sons Ltd., require a General Manager to take full responsibility of a very large modern Plywood Factory in the West Country. Applicants must be experienced production engineers conversant with the latest methods of controlling a mass production factory and with management problems generally. Some knowledge of wood helpful but not essential. Eligible for contributory pension scheme. Salary commensurate

with qualifications and experience. Write, with full particulars to: the Secretary, 130/150 Hackney Road, London, E.2.

Estimator. First class man, capable of preparing technical drawing estimates for multi spindle automatics, required by leading Midland tool manufacturers. Applicants should possess sound knowledge of modern tooling methods, supported by a good practical background. Applications addressed to the Personnel Manager, should state full particulars of career to date, age and indication of salary required to: Box No. 1044, I.Prod.E., 10 Chesterfield Street, London, W.1.

Chief Draughtsman required by Sentinel (Shrewsbury) Limited, to take charge of the jig and tool drawing office. Extensive experience in the design of jigs and fixtures for modern production methods is essential and some press tool experience would be an advantage. A substantial salary will be paid and a pension scheme is in operation. Applications which will be treated in confidence should state age, qualifications, experience and positions held with dates and be addressed to: Managing Director, Sentinel (Shrewsbury) Limited, Shrewsbury.

Time Study and Estimating Engineer required for factory in Kennington, London area, engaged on mechanical and electrical assembly work, and precision machined components. If necessary, training will be given to a suitable candidate with little Time Study experience, but who has had tool room training and has qualifications approaching Ordinary National Certificate. Good salary and prospects. Box No. 1045, I.Prod.E., 10 Chesterfield Street, London, W.1.

Estimating Engineer required in expanding organisation 30 miles from London. Applicants should be between 35/40 years of age, have a H.N.C. in mechanical or production engineering, and have experience of the telephone or electronic industry. Apply: Box No. 1032, I.Prod.E., 10 Chesterfield Street, London, W.1.

Development Engineer required by manufacturing company for the design and development of special purpose machinery. Applicants must have served an apprenticeship to mechanical engineering, minimum technical requirements H.N.C. Salary commensurate to experience. Applications giving details in chronological order should be addressed to: Chief Engineer, Permanite Limited, 455 Old Ford Road, London, E.3.

General Works Manager required for medium/heavy engineering in Manchester area to reorganise control in existing works and initiate control in new subsidiary works. Only fully qualified first class men considered. Commencing salary £1500 per annum. Box No. 1047, I.Prod.E., 10 Chesterfield Street, London, W.1.

Cam & Tool Designer Draughtsman required. Must be fully experienced on all types of single-spindle & multi-spindle automatic machines. Excellent conditions and wages. Apply: Davis & Timmins Limited, Billet Road, Walthamstow, E.17.

Production Engineer required by a group of ophthalmic prescription manufacturers. The head offices and one of the factories of the group are situated in Central London, while the other factories are in large provincial centres. The successful applicant would be required to spend some time at each factory and would be expected to initiate improvements in design of machinery and production methods. Previous experience in the optical industry is not necessary but applicants should be fully qualified engineers. Age 28-40. Salary according to qualifications and experience. Pension scheme in operation. Write, giving full details to: Box S.267, c/o Streets, 110 Old Broad Street, London, E.C.2.

General Manager required by large Manchester engineering company. Applicants must be qualified engineers with factory executive experience and have held senior sales or commercial appointment. Experience of textile spinning industry an advantage. The post offers advancement to directorship and substantial remuneration. Apply, stating age, appointments held and salary required to: Box No. 1048, I.Prod.E., 10 Chesterfield Street, London, W.1.

Designers. A well-established engineering firm in the West of England requires first class designers experienced in any of the following fields: printing, boxmaking, and allied machinery. Preference given to practical men of proven ability. Good working conditions. 36½ hour week. Staff pension scheme. Interesting and varied work. Salary commensurate with ability. Apply in writing, giving full details of training and experience, to: Box No. 1049, I.Prod.E., 10 Chesterfield Street, London, W.1.

Jig & Tool Draughtsman needed for excavator division of Newton Chambers & Company. Age 25-30, with experience of designing jigs and fixtures for machining and assembling medium sized components. The post is permanent and pensionable with excellent prospects for the selected draughtsman. Please reply, giving details of age, experience and present salary to: Personnel Officer, Newton Chambers & Co. Ltd., Thorncliffe, Sheffield.

Plant Engineer required to take charge of large maintenance department of general engineering and fabricating firm in S.E. London. Should be in age range 35-45, have served an apprenticeship and had subsequent experience on maintenance of plant and factory services. A.M.I.Mech.E. and experience in drawing office an advantage. Position is of managerial status and will carry a substantial salary and superannuation benefits, etc. Company may be able to help with suitable housing accommodation. Replies, stating full details of age, experience and present salary will be treated in strictest confidence. Box No. 1050, I.Prod.E., 10 Chesterfield Street, London, W.1.

Senior Jig and Tool Draughtsman required on the tooling of heavy vehicle components. Permanent and pensionable post for right man. Apply: Transport Equipment (Thornycroft) Limited, Basingstoke, Hants.

Deputy Chief Ratefixer required by Electrolux Limited. Applicants, aged 30/40, must be fully trained in motion work study techniques, have had a minimum of five years experience as a senior time study engineer on press and sheet metal work, machining, welding, plating and painting; be conversant with production line technique and possess strong personality, with the ability to negotiate individual and group incentives. This is a first-class opportunity for the right man, salary depending on knowledge and experience. Write with full details of past experience to: Personnel Manager, Electrolux Limited, Luton.

Assistant to the Production Manager required by London firm (Works in the Aldgate area) of light engineers engaged in the manufacture of equipment for the food and brewery trades. Applicants should have had some experience in production of light machine assemblies and be able to carry work through from drawing office to erection stage. Applicants should be between 23 and 28, and the salary is in the region of £450 - £500. Apply to: Box No. 1046, I.Prod.E., 10 Chesterfield Street, London, W.1.

Works Manager. Engineering concern of long standing requires Works Manager about 35, able to plan and run engineering workshop S.W. London, manufacturing specialities and later machine tools, starting from scratch. Must have had good technical and practical background and also previous experience in control of labour. Salary according to ability and experience. Excellent prospects. Box No. 1051, I.Prod.E., 10 Chesterfield Street, London, W.1.

Sales Engineer required by leading firm of tungsten carbide and machine tool manufacturers for sales promotion and technical representation for tungsten carbide tooling and applications in London and the Home Counties. Candidates should be approximately thirty years of age with apprenticeship training and an H.N.C. in either mechanical

or production engineering. Good remuneration and prospects. A company's car will be available with the post. Box No. 1052, I.Prod.E., 10 Chesterfield Street, London, W.1.

Specialist Engineer. National Coal Board invite applications for superannuable appointment of a Specialist Engineer in the workshops and building section of production department at London headquarters. Duties include advising upon plant, equipment and services layout in the Board's workshops and upon modern methods of production control, involving visits for varying periods to the Board's workshops in the coalfields. Applicants should have a recognised technical qualification, and wide experience of planned reconditioning of mining or similar types of machinery. Salary on appointment, depending upon qualifications and experience, in range £650 to £1,250 inclusive. Write, giving full particulars (in chronological order) of age, education, qualifications and experience (with dates) to: National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1., marking envelope TT/937. Original testimonials should *not* be forwarded. Closing date 12th April, 1955.

Technical Manager. A West Riding firm manufacturing domestic equipment is planning to expand its product range and output. A fully qualified production engineer is required to control, as Technical Manager directly responsible to the Managing Director, the department covering methods engineering, work study, layout and quality control. The position will give great scope for initiative action to a man with a background in a similar capacity and the salary will be commensurate with the responsibility. A pension scheme is operated and assistance will be given if removal is involved. Candidates should detail, in confidence, age and education, qualifications and experience, in letters to be addressed to: Box No. 1053, I.Prod.E., 10 Chesterfield Street, London, W.1.

Engineer. PERA requires an engineer with experience in the development of organisational systems, particularly production control, costing and maintenance systems. The work is varied and interesting and may include visits to engineering firms throughout the country. Annual increments on merit. Supperannuation under F.S.S.U. Applications giving details of age, experience, qualifications and salary to: the Secretary, Production Engineering Research Association, Melton Mowbray, Leics.

Assistant to General Manager. The excavator division of Newton Chambers & Company Limited, have a vacancy for a graduate production engineer, to act as Personal Assistant to the General Manager of the division. Applicants who should be in the age range 30-35 must have had at least 5 years experience in production engineering. For the right man there are prospects of advancement. The position is superannuable. Applications giving full particulars including age, education, experiene and salary required should be made to: Personnel Officer, Newton Chambers & Co. Ltd., Thorncliffe, Nr. Sheffield.

EDUCATIONAL APPOINTMENTS

University of Nottingham, Nottingham.
Cripps Chair of Production Engineering.

Applications are invited for election to the Cripps Chair of Production Engineering which has recently been established. Present salary is £1,850 per annum, but salary scale is under review. Intending candidates are requested to notify the undersigned immediately and if from overseas this should be done by cable or air mail.

Barnsley Mining and Technical College, Barnsley.
Assistant Grade A. An Assistant Grade A is required to teach workshop practice and engineering subjects in Ordinary National Certificate and City and Guilds Courses. Candidates should hold the Higher National Certificate in Mechanical (or Production) Engineering and/or the final certificate of the C.G.L.I. in Machine Shop Engineering. Application forms obtainable from the Principal, and should be returned within two weeks of the appearance of this advertisement.

Southall Technical College, Beaconsfield Road, Southall, Middlesex.
Assistant (Grade B) in Mechanical Engineering.

Applications are invited for the post of Assistant (Grade B) in Mechanical Engineering. The work will be concerned with the teaching of engineering workshop practice and allied subjects in machine shop engineering courses leading to the Intermediate and Final examinations of the City and Guilds of London Institute. Applicants should possess sound technological qualifications and have good industrial experience with modern machine tools. Duties to commence if possible in April but not later than 1st September, 1955. Salary scale £525 by £25 to £820 per annum plus London allowance (£36 or £48). Application forms (stamped addressed foolscap envelope) from the Principal to whom complete forms should be returned not later than 11th March, 1955.

Acton Technical College, High Street, Acton, W.3.
Lecturer in the Department of Management and Production Engineering. Applications are invited for the post of Lecturer in the department of management and production engineering. Applicants should be prepared to develop with industry: (i) collaborative teaching in production engineering relating its technical aspects to its social aspects; (ii) machine shop projects and laboratory work suitable (a) for production engineering and methods studies, (b) for demonstrating display-control relationships or other human and "ergonomic" factors in technical operations. Some teaching in such Higher National Certificate subjects as plastics technology, press tools, jig and tool design may be required. Qualifications should include industrial experience and a degree (or its equivalent) in some branch of engineering or science. There will be an opportunity of working with an existing social research team. Salary in accordance with the Burnham (Technical) Report, 1954. Forms of application (stamped addressed foolscap envelope) from the Principal to whom completed forms should be returned within fourteen days of the appearance of this advertisement.

Denbighshire Technical College, Wrexham.
Lecturer in Production Engineering. Candidates should possess an engineering degree or equivalent qualifications and professional qualifications. Industrial and teaching experience essential. Successful candidate will be required to teach one or more of the following subjects to H.N.C. standard: workshop technology, machine tools, metrology, jig and tool design and workshop technique to final City and Guilds of London standard. Salary in accordance with Burnham (Technical) Scale. The authority will assist in providing housing accommodation. Application forms, obtainable from: Director of Education, Education Offices, Ruthin, and must be returned within a fortnight of the appearance of this advertisement.

A CONFERENCE ON
"COMPRESSED AIR AS AN AID TO PRODUCTIVITY"

has been arranged by the

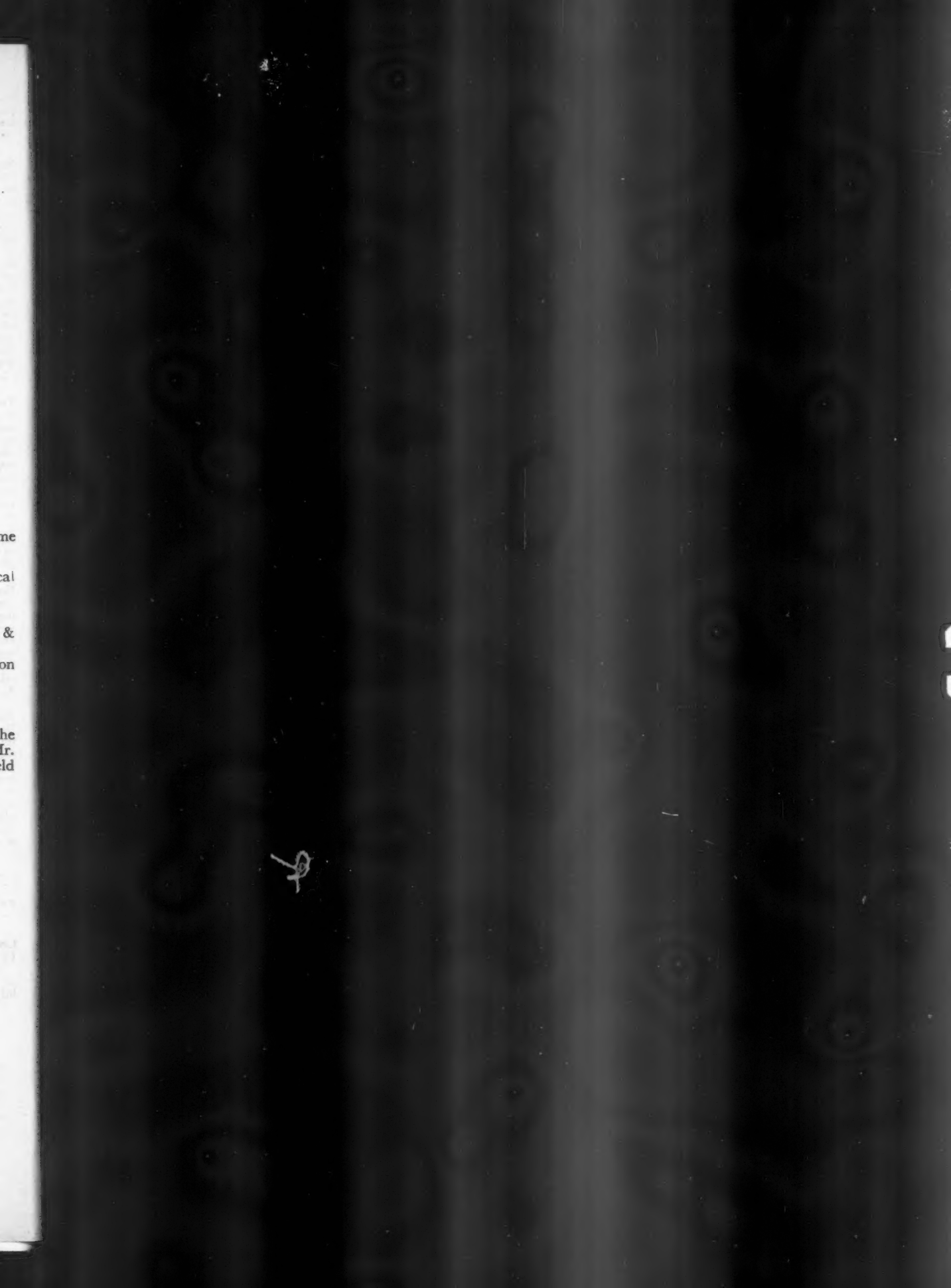
CORNWALL SECTION OF THE INSTITUTION

to take place at the

CORNWALL TECHNICAL COLLEGE, TREVENSON, CAMBORNE
13th/14th APRIL, 1955

The Conference will be opened by the President of the Institution, Sir Walter Puckey, and the programme will include the following lectures:

1. "Compressed Air and Its Compression," by J. R. Quertier, B.Sc., A.C.G.I., A.F.R.Ae.S., Hon. Technical Director, British Compressed Air Society.
2. "Air Operated Tools," by F. B. Coombes, A.M.I.Prod.E., Chief Designer, Holman Bros., Ltd.
3. "Air Operated Equipment," by W. G. Bennett, B.Sc., M.I.Prod.E., Manager, Climax Rock Drill & Engineering Co., Ltd.
4. "A User's Experience," by W. E. Wright, A.M.I.Prod.E., Chief Planning Engineer, Engine Production Factory, Bristol Aeroplane Co., Ltd.

A number of works visits and demonstrations of pneumatic equipment have also been arranged.

The Conference Fee is 25s. for members of the Institution, and 30s. for non-members. Full details of the programme and application forms may be obtained from the Hon. Secretary of the Cornwall Section, Mr. F. G. Hawke, 17, Church Road, Pool, Redruth, Cornwall, or the Secretary of the Institution, at 10, Chesterfield Street, London, W.1.